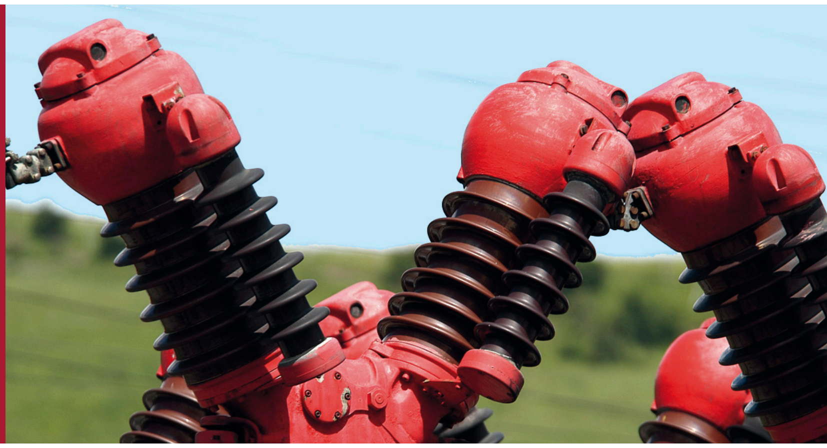
6IRV

Breaker Protection & Control IED



Instructions Manual for **6IRV** Models
M6IRVA1811Iv02

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Chapter 1.

Description and Start-Up

1.1 Functions

The IED generically designated as **6IRV** combines all the necessary functions required for full control, supervision and protection of a breaker. These IEDs use the most advanced digital technology based on powerful microprocessors and DSP's, and incorporates Breaker Failure protection, Recloser and Synchronism Supervision. Also, **6IRV** relays incorporate backup protection units like Overcurrent, Over/Undervoltage, Over/Underfrequency as well as Control and Metering functions.

The **6IRV** Recloser allows for reclosing either single-phase or three-phase trips or both; four different modes of reclosing operation being possible in order to do so. Furthermore, prior to a reclosing command, it will optionally check synchronism, and this information can be supplied by the equipment Synchronism Unit. **6IRV** relays can perform 4 reclosing attempts. The **6IRV-B** relay recloser controls two breakers.

6IRV relays also include Command Logic to perform breaking and closing operations and generate from these operations as well as from tripping and reclosing commands, trip and close failure information.

6IRV relays incorporate backup protection units and combine Voltage Metering Units (Phase Over/Undervoltage and Ground Overvoltage), Current Metering Units (Phase, Ground and Negative Sequence, Dead Line, Fuse Failure, Thermal Image, Overexcitation, Brekaer Failure and Open Phase) and and Frequency Measurement elements (Over/Under Frequency and Frequency Rate-of-Change).

Also, Breaker Monitoring functions are provided to detect an excessive number of tripping operations. The terminal units are also equipped with up to three (**6IRV-A**) or six (**6IRV-B**) trip and close circuit supervision elements to detect breaker trip coil and close coil circuit failure.

Finally, the equipment includes functions for Oscillography Records (analog and digital channels), Fault Reports, Event Recording and Historical Metering Data Logging and Programmable Logic.

1.1.1 Phase, Ground and Negative Sequence Overcurrent Protection (3x 50/51 + 50N/51N + 50Q/51Q)

All models are provided with five overcurrent metering units (three for phase currents, one for ground and one for negative sequence current). Each unit is composed of three time delay elements and three instantaneous elements, with additional adjustable timer.

Time elements can be selected with the following types of characteristics, in accordance with IEC and IEEE/ANSI standards: Definite Time, Moderately Inverse, Inverse, Very Inverse, Extremely Inverse, Long-Term Inverse, Short-Term Inverse, RI Inverse, as well as any of them set up with Time Limit, and one User Definable curve.

These models have independent LED targets for each unit for the pickup and trip of the phase and neutral time and instantaneous elements. They can be directed to any logic signal.

All overcurrent elements can be adjusted as directional, and the directional unit in charge of taking the directional decision can be selected by setting.

1.1.1.a Overcurrent Protection with Polarization Channel

6IRV - *. ***** 1 *** or higher models have an additional metering unit (Polarization channel). This unit is composed of one instantaneous element, with additional adjustable timer

These models have independent LED targets for the pickup and trip of the IPol Channel instantaneous element, that can be directed to any logic signal.

1.1.2 Directional Units (3x67 + 67N + 67Q)

Phase Directional Units. One directional element is associated with each phase. Polarization is done by between-phase voltage with memory.
Ground Directional Unit. Includes double polarization

- By ground voltage.
- By grounding current.

Negative Sequence Directional Unit. Polarized by negative sequence voltage.

1.1.3 Undervoltage Units (3x27 / 1x27)

6IRV models are provided with three undervoltage units (three phases) that can be separately selected as phase or line voltage, each composed of three instantaneous elements with additional adjustable timers.

1.1.4 Overvoltage Units (3x59 / 1x59)

6IRV models are provided with three overvoltage units (three phases) that can be separately selected as phase or line voltage, each composed of three instantaneous elements with additional adjustable timers.

1.1.5 Ground Overvoltage Unit (1x59N)

All models are provided with two residual overvoltage metering elements. They take the measurement obtained by calculating the three phase voltages available in the IED.

Said metering units are composed of two instantaneous elements with additional adjustable timer.

1.1.6 Underfrequency (81m), Overfrequency (81M) and Rate of Change (81D) Protection

All the models have an analog voltage input for obtaining the frequency and nine metering units: 3 underfrequency, 3 overfrequency and 3 rate of change. Each of these units contains one element with an adjustable timer. You can set it as instantaneous.

1.1.7 Open Phase Unit (46)

All the models have an Open Phase unit to detect the opening or unbalance of one or more phases. When this is detected, the unit trips and eliminates the unbalance. It operates on a time characteristic with a fixed time adjustable timer.

1.1.8 Thermal Image Unit (49)

The **6IRV** model has a thermal image unit that uses the current circulating through the cables to estimate their thermal status in order to trigger a trip when they have reached high temperatures.

The unit provides separate alarm and tripping indications. You can direct both to the IED's configurable logic.

1.1.9 Breaker Failure (50BF)

The **6IRV** incorporates Breaker Failure protection with two time steps so that retripping (single or three-phase) of failed breaker can be produced, if required, prior to the tripping command of adjacent breakers.

Breaker Failure protection incorporates separate timers and overcurrent levels for single-phase and three-phase tripping. Pick ups generated by single-phase tripping incorporate overcurrent detectors and phase segregated timers in order to act correctly in the event of evolving faults. All overcurrent detectors have very fast resetting characteristics.

Also, this unit allows protection against breaker failure with no overcurrent and detects the presence of active internal arcing.

The **6IRV-B** relay breaker failure protection supervises two breakers.

1.1.10 Open Pole and Pole Discordance Detector (2)

The equipment incorporates Open Pole detection logic, which operates based on the position of the breaker contacts this being backed up by phase segregated current detectors. Said logic output is taken into account for the operation of a number of protection devices, due to various conditions generated by an open pole.

On the other hand, the equipment allows for the detection of breaker pole discordance condition, which could cause a trip if the condition remains unchanged for an adjustable time.

The **6IRV-B** relay open pole and pole discrepancy detector supervises two breakers.

1.1.11 Synchronism Unit (25)

Several elements are included in this unit: Line Voltage and Bus Voltage (with selectable energizing mask), Voltage Difference, Phase Difference, and Frequency Difference.

This unit can be set to supervise the reclosing function and block breaker closing when synchronous conditions are not satisfied.

The **6IRV-B** relay synchronism element supervises two breakers.

1.1.12 Monitoring of the Switching Circuits (3)

The IED has units for verifying the proper operation of the switching circuits of the breaker. The **6IRV-A** relay can monitor up to three coils and the **6IRV-B** relay up to six coils. You can monitor both breaker positions (open and closed) or either one of them.

1.1.13 Dead-Line Detector

The relay incorporates a Dead-Line detection element, which allows detecting deenergized lines based on the operation of two elements, undercurrent and undervoltage. The Dead-Line detector allows detecting the closing of the breaker (one line energized), so that can be used to activate the switch-onto-fault element with the benefit of not requiring external contacts for said activation.

1.1.14 VT Fuse Failure Detector

This element can block the trips based on voltage measurement (Phase Undervoltage, Ground Overvoltage, Synchronism and Weak Infeed Trip Logic) when loss of any secondary voltage of a voltage transformer is detected.

1.1.15 Single / Three-Phase Recloser (79)

The Recloser can be coordinated with external protection as well as with the protection contained in the IED.

A maximum of four attempts can selected, with independent settings for reclosing times. The reclosing sequence is controlled by the breaker position and by the reclose initiate signal.

The reclosing sequence after overcurrent and open phase units tripping will be determined according to the settings.

The Recloser features separate cycles for different tripping modes: single and three-phase, and the following operation modes can be selected:

- 1p Mode: reclosing for single-phase trips only.
- 3p Mode: reclosing for three-phase trips only.
- 1p/3p Mode: reclosing for both types of trips.
- Dependent Mode: only one reclosing attempt for three-phase tripping, and as programmed by the number of reclosing attempts setting for single-phase tripping.

The **6IRV-B** relay recloser controls two breakers.

1.1.16 Overexcitation Protection (24) (69V/Hz or 59/81)

All models are equipped with a unit to determine the overexcitation level of the protected machine. This unit has an element for determining the voltage/frequency ratio; the unit takes action if this value exceeds a certain setting.

It is possible to delay the activation of the trip output following o definite time or inverse characteristic.

1.1.17 Stub Bus Protection (50STUB)

Said element is applied to one-and-a-half-breaker scheme or ring substations. Its purpose is protecting the area between the two current transformers and the line sectionalizer when the latter is open. This time phase overcurrent element is activated when the line sectionalizer opens. The **6IRV-B** relay stub bus protection incorporates a restraint algorithm that gives more stability on external faults.

1.2 Additional Functions

1.2.1 Control local

You have five buttons on the front of the IED for operating on the system's configurable elements in the IED (Lockout, Breaker, Sectionalizers, Recloser Function, Programmable Control Functions, Protection Units, Local/Remote, Active Group of Settings, etc.) and for resetting the operation LEDs.

1.2.2 Programmable Logic

An operational logic can be programmed in order to set up blockings, automatic controls, control and trip logic functions, command hierarchy, etc through logic gates combined with any captured or equipment-calculated signal.

All the signals generated by the equipment will be available to the events, fault reports, oscillograph records, digital inputs and outputs, HMI and communications according to how their programmable logic has been configured.

The processing of the input signals produces logical outputs that can be assigned to existing connections between the **6IRV** and the exterior: auxiliary output contacts, display, communications, LEDs, HMI…

1.2.3 Ports and Communications Protocols

6IRV relays are provided with different types of communications ports:

- **1** front **Local Port** type RS232C and USB.
- Up to **3 Remote Ports** with following configurations:
    - Remote Port 1: optical fiber interface (glass ST or plastic 1mm) or electrical interface RS232 / RS232 FULL MODEM.
    - Remote Port 2: optical fiber interface (glass ST or plastic 1mm) or electrical interface RS232 / RS485.
    - Remote Port 3: electrical interface RS232 / RS485.
- **2 LAN Ports** with RJ45 connector or glass optical fiber MT-RJ for ETHERNET type communications.
- **1 Remote Port** with CAN protocol BUS connection.

The IED also has the following communications protocols: PROCOME 3.0, DNP 3.0 and MODBUS. You can assign any one of them to both remote ports. For PROCOME it can be also assigned to the LAN ports; IEC-61850 (LAN ports) and CAN (electric BUS CAN). The local port supports the PROCOME 3.0 Protocol. It is for parameter setting, configuration and retrieval of information about the IED.

Protocol changeover trailers are totally independent for each port, and two same-protocol instances can be maintained in the two remote ports.

1.2.4 Supervision of the Switching Circuits

The IED has units for verifying the proper operation of the switching circuits of the breaker. They can monitor up to six coils. You can monitor both breaker positions (open and closed) or either one of them.

1.2.5 Breaker Monitoring

To have information for maintaining the breaker, the IED has a unit that sums and accumulates the kA^2 values each time it trips.

1.2.6 Excessive Number of Trips

This function prevents the breaker from making an undesirable number of operations in a given period of time, which may result in breaker damage. When the maximum number of trips allowed is surpassed, the Recloser function is blocked.

1.2.7 Selecting the Phase Sequence

You can configure the connection of the IED to the network sequence when the phase sequences are ABC or ACB.

1.2.8 LED Targets

There are five LEDs (2U or 3U high models) located on the left side of the front panel. Four are configurable and one indicates IED **In Service**. There are sixteen LEDs (4U or more high models), and one more indicates IED **In Service**. All of them are located on the left and right sides of the front panel. Configurable LEDs light in red when are activated and **In Service** LED does it in green.

1.2.9 Digital Inputs

The number of digital inputs available will depend on each particular model (see 1.5, Model Selection) and may vary from 8 up to 82.

1.2.10 Auxiliary Outputs

The number of auxiliary outputs available will also depend on each particular model (see 1.5, Model Selection) and may vary from 6 up to 50. One of these outputs is not configurable as it is assigned to the relay “In Service” indication.

1.2.11 Time Synchronization

The IEDs include an internal clock with a resolution of 1 ms. This can be synchronized via GPS (IRIG-B 003 and 123 Protocol) or by communications through remote communications port (PROCOME 3.0 or DNP 3.0 Protocols).

1.2.12 Event Recording and Programmable Metering Data Logging

Storage capacity of 400 annotations in a non-volatile memory. Event-generated signals can be selected by the user and are annotated with 1ms resolution and a maximum of 12 measurements also user-selected.

1.2.13 Fault Reporting

Storage capacity of up to 15 fault reports with relevant information, such as units picked up, units tripped, pre-fault values, fault values, current interrupted by breaker, etc.

1.2.14 Historical Metering Data Logging

Historical metering data logging allows for obtaining twelve maximum and twelve minimum values from a group of four magnitudes selected out of all available measurements (captured or calculated), except meters, for each time window. This window can be adapted to the application by adjustment of day and interval masks. Up to 168 records can be saved.

1.2.15 Oscillographic Register

The Oscillographic Recording function is composed of two different sub functions: **Capture** and **Display**. Both analog magnitudes and internal signals as well as digital equipment inputs will be recorded, up to a total of 64 oscillograms in a circular memory. Sampling and storing frequency is 32 samples per cycle with 15 seconds of total storage.

Oscillograms are delivered in format COMTRADE 99. A program for the display and analysis of the captured oscillograms is supplied with the equipment.

1.2.16 Long Term Oscillographic Register

According to the model, the device includes a second oscillographic function, which is capable of storing (according to the sample frequency setting) up to a maximum of 256 oscillos of 10 seconds each. Four voltages (3 phases and synchronous voltage) are recorded. They are selected by setting the storage to 32 samples per cycle, 16 samples per cycle or by setting the storage to an effective value for each signal cycle.

This oscillographic function has independent signals and settings. It operates in a similar manner to the main oscillographic register (see previous section) in terms of startup functions and COMTRADE file format.

1.2.17 DC Power Monitoring

Some models include a function for monitoring the voltage supplied by the substation’s DC battery and used to power the equipment.

This monitoring allows overvoltage and undervoltage alarms to be generated, also making it possible to generate a log of voltage values and store them in the ocillographic records that can accompany each use of the equipment.

To perform the monitoring, the equipment includes an input transducer specifically designed to measure the prevailing direct current values in the substations.

1.2.18 Virtual Inputs / Outputs

The virtual inputs/outputs function allows the bi-directional transmission of up to 16 digital signals and 16 analog magnitudes between the two **6IRV** units connected through a digital communications system. This function allows to program logics which contain local and remote information, analog as well as digital.

1.2.19 Alphanumeric Display and Keypad

- Changing and displaying settings.
- Protection operations:
  - Last trip and Recloser status.
  - Units picked up.
  - Tripped units.
  - Contact input and output status.
  - Counters status (reclosing and kA^2)
- Protection records (displayed via communication):
  - Event recording.
  - Fault report.
  - Log file of currents, voltages, powers, power factor and energies or other calculated values.
- Control records.
- Metering values used by protection:
  - Phase and ground currents and angles.
  - Line currents.
  - Polarization current.
  - Voltage of three phases and ground (and their angles).
  - Line voltages.
  - Synchronism voltage.
  - Positive, negative and zero-sequence currents.
  - Positive, negative and zero-sequence voltages.
  - Active, reactive and apparent powers and power factor.
  - Energies.
  - Frequency.
  - Thermal value.

1.2.20 Graphic Display

The graphical display is fully configurable. The possible functions to show could be:

- Position mimic indicating the state of the different elements.
- Local Control of the elements.
- Measurements panel (reals and calculated).
- Alarms panel.
- I/O state information.

1.2.21 Self-Test Program

A continuously running diagnostic self-test program verifies the correct operation of the terminal unit and alerts the user of potential problems.

1.3 Local Interface: Alphanumeric Display and Keypad

1.3.1 Alphanumeric Display & Keypad

The liquid crystal alphanumeric display has a 4-row by 20-character matrix. It displays information about relay alarms, settings, metering, states, etc. There are 4 function keys (F1, F2, F3 and F4) under the display. The next section explains their functions. Figure 1.3.1 shows the default graphic display and the function keys.

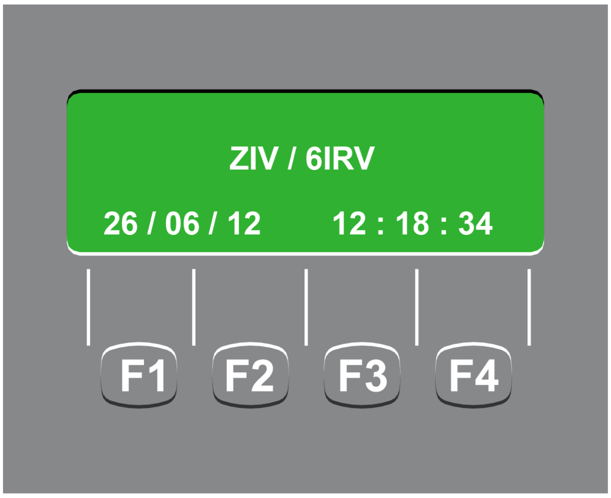


Figure 1.3.1 Alphanumeric Display.

The display resolution talking about meterings depends on the measurement which is going to be shown, defined inside Chapter 2.1, measurement accuracy or in the control logic side of the relay.

- **Default Display**

Figure 1.3.1 depicts the default display showing the relay model, the date and the time. The upper left corner also indicates the connection mode (if communication has been established):

[PL] Local connection (communication through the front port)
[P1] Remote connection (communication through rear port 1)
[P2] Remote connection (communication through rear port 2)
[P3] Remote connection (communication through rear port 3)

- **Keypad Associated with the Display**

The keypad consists of 16 keys arranged in a 4 x 4 matrix. Their properties are specified next. Figure 1.3.2 shows the layout of this keypad.

In addition to the keys corresponding to the digits (keys from 0 to 9), there are the selection keys (↑ and ↓), the confirmation key (ENT), the escape key (ESC) and the contrast key (◑).

Starting with the default screen, operations can be performed on **6IRV** system functions in two different ways: using one single key (F2) or using the whole keypad.

Figure 1.3.2 Keypad.

1.3.2 Control Buttons

There are three columns of buttons for operating on the system units, settings groups and protection elements configured in the relay.

The first column contains the I and O buttons (close and open commands respectively), as well as the breaker selection button. This button is accompanied by 1 LED (red=open / green=closed) indicating the breaker status.

1.3.2.a Programmable Buttons

The next 2 columns are made up of six programmable buttons (P1 to P6) for operating on the elements / units that the user determines using the communications program, together with a space for displaying the description of that button's function. Each of these six buttons in turn has a configurable LED that indicates the state of the object / function associated with that button. The function of these buttons is to select the unit to be operated upon. The command is sent to the unit with the (I) and (O) buttons.

The push-button group has a general interlock that can be configured from the HMI or via the communications ports providing the security required for proper operation.

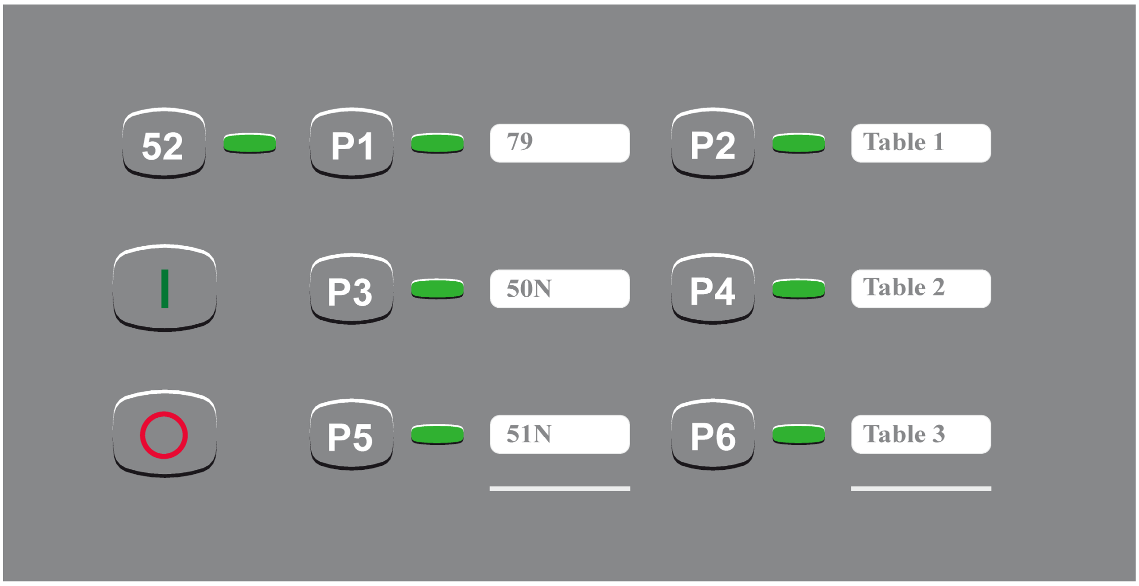


Figure 1.3.3 Control Buttons and Programmable Buttons.

1.3.3 Keys, Functions and Operation Modes

This section explains the alphanumeric display's function keys and the keypad's digit keys.

1.3.3.a Keypad

Confirmation Key

The ENT key is used to confirm an action: after making a selection or after editing a setting and to advance to view all the records. After any operation (selection, change of settings, information, etc.), pressing ENT again accesses the immediately preceding level.

Escape Key

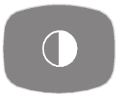
The ESC key is used to exit a screen if the setting is not to be changed or simply to exit an information screen. In any case, pressing this key returns the display to the immediately preceding screen.

Display Selection Keys

The selection keys are for advancing or returning, in correlative order, to any of the options of a menu or a submenu. When a menu has more than four options, an arrow (↓) will appear in the lower right corner of the display indicating that there are more. The ∇ key brings up the second set of options.

An arrow (↑) will appear in the upper right corner of the display to indicate the existence of the first set of options.

The ∇ key is also used to delete digits within a setting that is being modified. It only has this function when a setting is being entered.



Contrast Key and Minus (-) Sign

Pressing this key brings up the screen for adjusting the contrast of the display. The selection keys modify this contrast value: greater value = less contrast. Also, when setting floating point values, it permits entering a negative sign (-).

1.3.3.b Function Keys

F1 Pressing F1 confirms changes in settings (when the relay requests such confirmation) and confirms the activation of a settings group (when the relay requests this confirmation).

When pressed from the stand-by screen, it provides access to the information provided by the sequential events recorder.

F2 The F2 key is used to consult the relay for information relative to measurements of current, voltage, power, etc. and to lock / unlock the recloser function, to reset the last trip indication and to reset LEDs and reclose counter among others.

F3 Pressing F3 displays the state of the relay's digital inputs and outputs.

F4 Pressing the F4 key rejects changes in settings (when the relay requests confirmation of the changes) and rejects the activation of a reserve settings group (likewise when such confirmation is requested).

1.3.3.c Accessing the Options

The digit keys (0 to 9) are used to directly access the options (settings, data, measurements, etc.). This direct access consists in successively pressing the identification numbers that the screen displays prior to each setting or option within the corresponding setting.

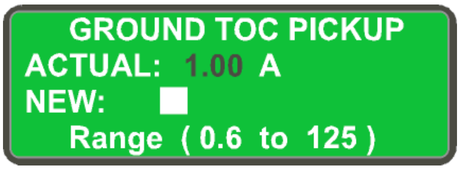
Another way to access the options consists in navigating the menus with the selection keys and then confirming the option selected with ENT.

1.3.3.d Operation

- **Change of Settings (Range)**

The change of settings (Range) presents the following arrangement: the operational value of the setting appears in the place indicated by the word ACTUAL. The new value is entered where a blinking cursor indicates the place in the next line indicated by the word NEW.

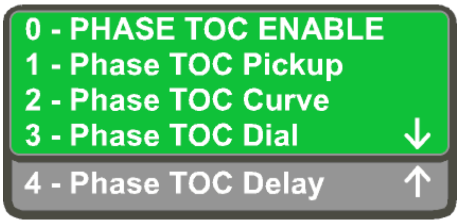
The digit keys are used to edit the new value, which must agree with the range specified in the last line of the display. If an error occurs upon inputting a value, the ∇ key will erase it. Once the new value has been edited, pressing ENT confirms it and exits to the preceding menu.



There is a type of setting that follows this outline but with a range limited to the options, YES and NO. In this case, the 1 and 0 keys correspond to the values YES and NO. Then pressing ENT confirms the setting and returns to the preceding screen.

- **Change of Settings (Options)**

These settings are presented in an options menu which is selected by either of two already known procedures: with the direct access number associated with the option or by using the selection keys and confirming with ENT. In both cases, the system returns to the preceding screen.



- **Settings of Masks**

Every option is listed in vertical order. Next to each option the setting is displayed by the box: full (■) for enable and empty (□) for disable.

The mask can be modified (in the line between brackets) using the key 1 (enable) or 0 (disable).

If there are more options than lines in the screen a down arrow (↓) will be included at the end of the last line. The second screen will be displayed after adjusting the last setting in the first screen.

- **Exit Menus and Settings**

Pressing the ESC key exits a menu or a setting without changing it. Pressing either ENT or ESC indistinctly exit an information screen. In either case, the display returns to the preceding menu.

1.3.4 Last Trip Indication

If there has been a trip, the relay will present its data first. This information is presented as follows:

As the various types of elements generate trip, additional screens are created. The format is always similar: a header line indicating the type of unit tripped (for example, Time current) and, below that, all the operated units and phases (Time1 A, Time1 B, etc.). If several functions trip and they do not fit on one screen, the selection keys allow accessing all that are generated.

If there have been no trips since the last reset, this screen is not presented.

1.4 Local Interface: Graphic Display

1.4.1 Introduction

The graphical display is only mounted in models **6IRV** and this chapter is only about its operation as well as the operation of the associated function keys (figures 1.4.1 and 1.4.2). The examples depicted are intended to explain display operation.

1.4.2 General

Graphical displays are LCD 114 x 64 mm (240 x 128 pixels). They are provided with own illumination and include five keys with following functions:

Functions	Designation	Color
Configurable	O	Red
Configurable	I	Green
Configurable	TAG	Blue
Selection	NXT	Gray
Information	INF	Gray

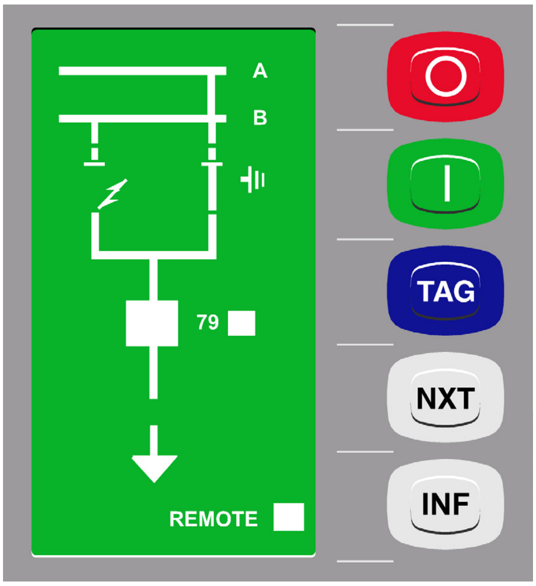


Figure 1.4.1 Local Control Graphic Display.

As shown in table, the first three keys (**O**, **I** and **TAG**) are configurable thus their function must be defined through the programmable logic. That is not so for **NXT** and **INF** keys that already have a function assigned to them.

Two options are available to operate the graphical displays: press function key **INF** to display the information screens or press **NXT** function key to display the different mimic objects and operate on them. Information screens and objects are displayed in sequence. Starting from any information screen, if the **INF** key is not pressed again within an adjustable time the system returns to the default screen. Also, if **NXT** key is not pressed within 10 seconds the system returns to the screen with no element selected.

Press **NXT** within the time-out period to select mimic objects one after the other until the situation of no element selected is reached again. Selected elements are represented graphically by a flashing symbol. This symbol may be created by the user or taken from the databases of the program, as described in figure 1.4.2 (as a function of their state).

Screen sequence can be selected, and a position mimic can be defined indicating the state of the different elements. Elements depicted in the single line diagram depend on the information associated to each of them. All this information is defined in the user configuration loaded into the relay.

1.4.3 Symbols associated to the Graphic Display

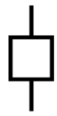
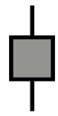
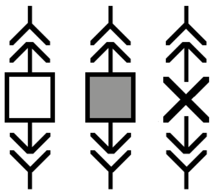
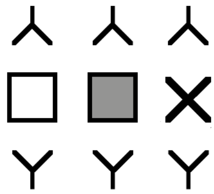
Element	State 1	State 2
Breaker	 Open	 Closed
Breaker	 Unknown (0-0)*	 Unknown (1-1)*
Switch	 Open	 Closed
Position of the Breaker mechanism	 Plugged	 Unplugged
Position of the Breaker mechanism	 Pulled out closed	 Pulled out open
Recloser	79 ■ In Service	79 □ Out of Service
Capacitor Bank Control	AUT ■ Automatic	AUT □ Manual
Voltage Regulator	90 ■ Automatic	90 □ Manual

Figure 1.4.2 Device Representation Symbols.

Device representation on display will depend on the state of one or several digital signals, the following representation objects being possible:

- Base.
- Command object.
- 2 state object.
- Magnitude object.
- Text object.

- **Base**

This object is the starting point for screen design. It can be created by the user or it can be taken from the program database.

Static parts (Busbars or ground connections) or the different alarm display boxes are base examples.

- **Command Object**

Command objects represent objects able to adopt a number of states varying from 1 to 16. Furthermore they can be operated from graphical HMI provided object attributes are configured as selectable.

Multi-state (Open, Closed and Unknown) breakers able to perform opening or closing operations are examples of command objects.

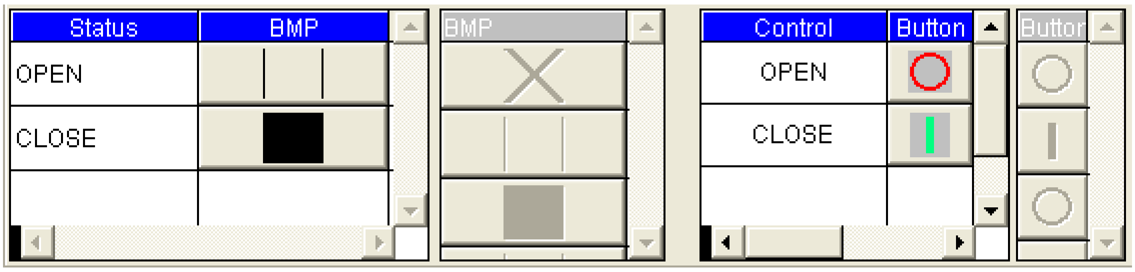


Figure 1.4.3 Example of Breaker State and Operations.

- **2 State Object**

2 state objects represent objects able to adopt one of two states as a function of the value of the digital signal to which it is associated (Deactivated= signal to 0; Activated = signal to 1). Objects may not be operated from graphical HMI their state only being modified when changing the signal value.

Examples of 2 state objects are voltage presence indicators or alarm display signals.

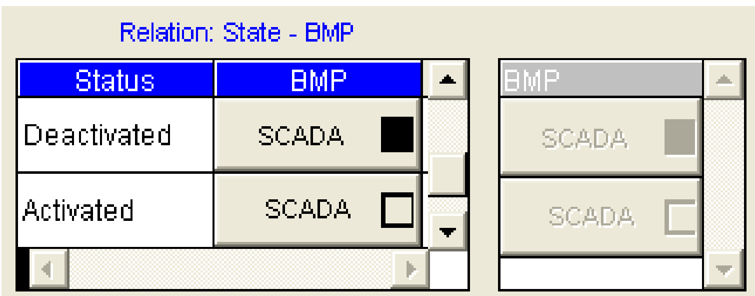


Figure 1.4.4 Example of 2 State Element.

- **Magnitude Object**

Magnitude objects allow displaying both Static (relay default) and User (created through programmable logic) magnitudes.

- **Text Object**

Text objects allow displaying text fields. Maximum number of characters allowed is 16.

It is worth mentioning that all types of objects can be displayed in the same screen, allowing this way for more freedom in screen design.

1.4.4 Access to Information

Press **INF** key for sequential display of accessible information screens on the graphical display.

It is worth highlighting that starting from any information screen, if **INF** is not pressed again within an adjustable time, the system returns to the default screen.

This time setting can only be displayed from the **Configuration** - **Graphical HMI Conf.** its range being from 0 to 60 seconds. A setting of 0 seconds disables the automatic return to the default screen. A **Contrast** setting, within the same option, is available, which affects only the graphical display.

The only default screens are **Digital Output** and **Digital Input** state screens. All other screens and the display sequence are defined through programmable logic.

1.4.4.a Alarm Display

Alarm display appearance as well as the number of screens and alarms to be shown can be designed through programmable logic. Also, digital signals associated to each alarm must be specified as well as the text to be shown on the graphical display.

It is worth mentioning that there are no definite type of screens for alarm display function. Said screens are created in a similar manner than for the rest of graphical display screens, using same objects described in paragraph 1.4.2. This allows maximum flexibility for screen design adapting screens to user needs.

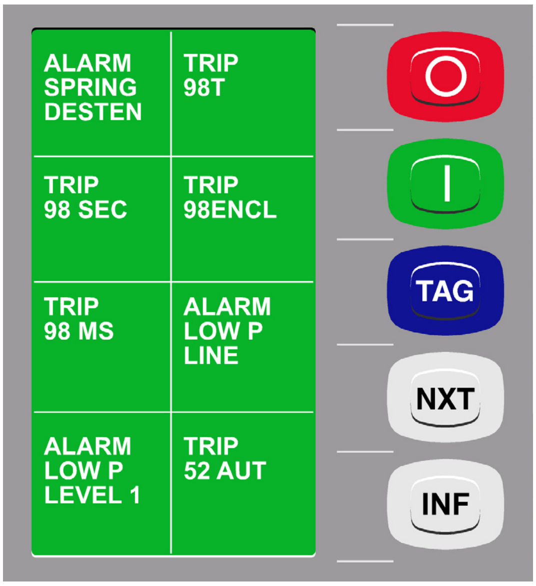


Figure 1.4.5 Example of Alarm Display.

Alarm acknowledgement functions are also defined through programmable logic, which must actuate on the digital signals associated to each alarm.

1.4.4.b I/O State Information

As mentioned in paragraph 1.4.3, **Digital Outputs** and **Digital Inputs** state screens are the only relay default screens. Said screens are not configurable and will thus be different for each model.

New screens can nevertheless be created, in which the state of any digital relay signal whether definite or created through programmable logic is shown.

Digital inputs or outputs are represented by a full rectangle (simulating a LED) if active, whereas the rectangle will be empty if inactive.

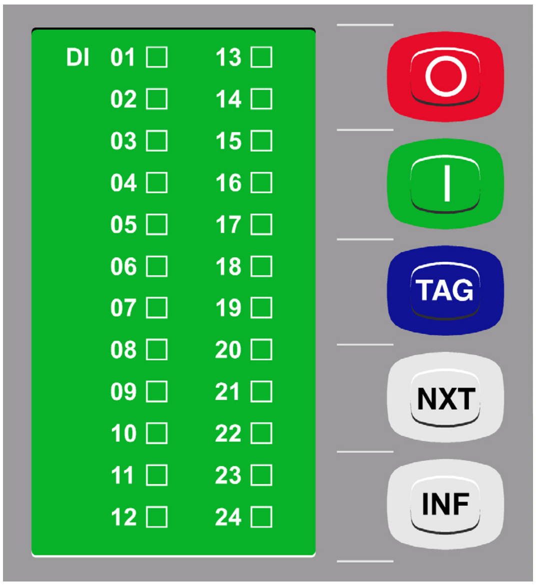


Figure 1.4.6 I/O Display.

1.4.4.c Measurements Information

A screen can be designed for representing relay measurements. As for digital signals, both definite relay measurements (static) and created through programmable logic can be used. No difference exists at the time of using them into the graphical display.

Time is a special measurement. Said static magnitude designated **Present Time** allows representing separately relay date and time.

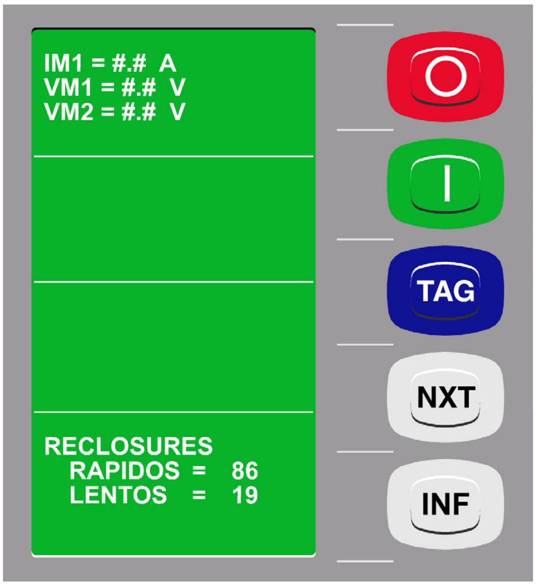


Figure 1.4.7 Example of Display with Measurements.

1.4.5 Control Function Operations

Control functions are mainly performed through graphical displays with the help of the 5 above described control keys.

Action on position elements is conditional on programming a **Command** within the programmable logic and the analysis of said logic on whether said action is feasible or not

1.4.5.a General Procedure for Command Execution

Command execution always follows the same sequential steps no matter the type of the operated device, allowing for easier relay operation.

Every time after pressing the **NXT** key, existing devices are highlighted in sequence and periodically in the position on which commands can be executed. Said highlighting consists in the device image flashing with a 1 second cadence. If after selecting an image no command is received within ten (10) seconds, the module will automatically cancel the selection, returning to the default state corresponding to no element selected. The image part flashing during the selection corresponds to the entire symbol except associated texts.

The established selection sequence can be configured at the time of performing the programmable logic. For a specific position the following sequence could be taken as an example:

- LOCAL / REMOTE Status
- Panel CONNECTED / DISCONNECTED Status
- Busbars sectionalizing switch
- Breaker
- Associated devices (automatic device recloser etc..)
- Busbars side grounding breakers
- Line side grounding breakers
- By pass breakers and finally nothing

After selecting the element to be commanded press the command key. As a general rule configurable close (**I**) or open (**O**) keys will be used.

If by any reason the command cannot be executed, two text lines will be shown on the relay display stating that execution is impossible as well as the reasons why said command cannot be executed. The following can be some examples:

LINE 1: COMMAND NOT-EXECUTABLE
LINE 2: TAGGED
INTERLOCK
POSITION IN REMOTE CONTROL

These statements are automatically erased after 5 seconds. No operation may be performed within this time.

The possible causes for a COMMAND NOT EXECUTABLE are defined through programmable logic. To this end, at the time of defining a new command, possible digital signals disabling command execution must also be defined. This way, when trying the command a message is displayed with the name of said signal.

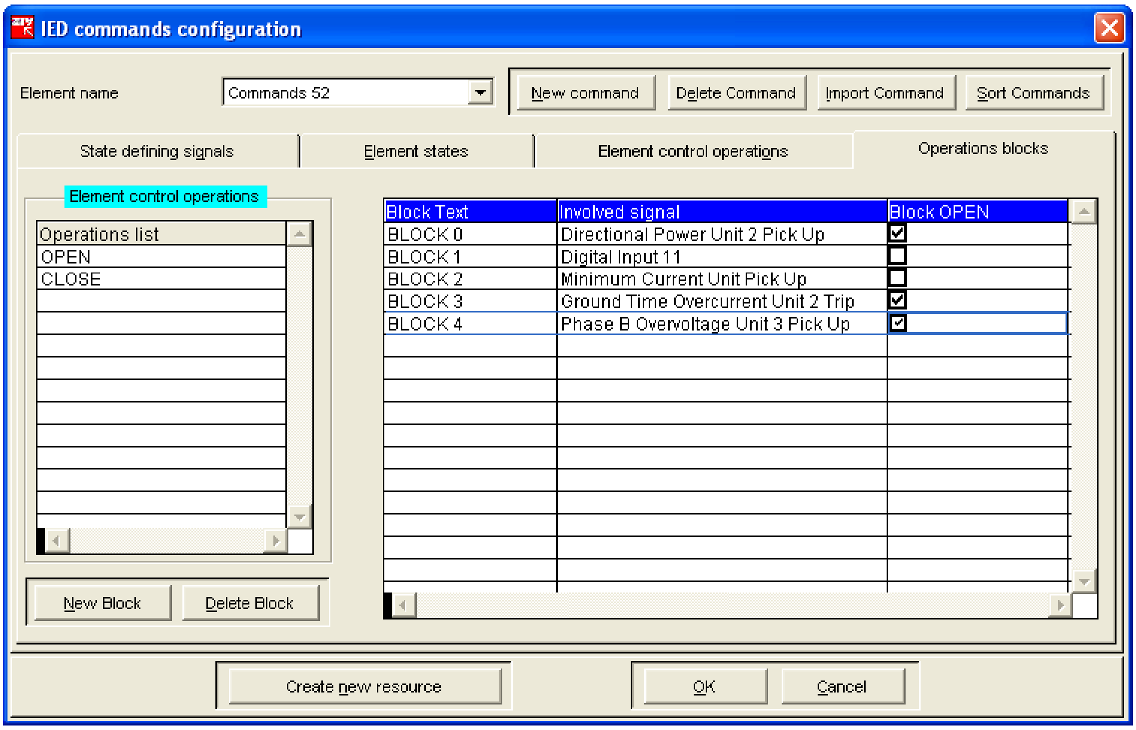


Figure 1.4.8 Example of Command Definition Screen.

This blocking signal can be any digital relay signal. That is, both definite (e.g. Digital inputs or Protection unit outputs) and created through programmable logic and as a result of the supervision of a set of data.

After verifying that the command can be executed, the relay checks the correct command execution through digital inputs or internal logic signal monitoring. If after an established time (selectable for each control) the command is detected to have failed, a screen message is displayed corresponding to COMMAND FAILURE of the same characteristics than above mentioned. If the command has been executed correctly, no external statement is displayed.

1.5 Model Selection

1.5.1 Model Selection

6IRV												
	1	2	3	4	5	6	7	8	9	10	11	12

1	**Functions**			
	A	Standard: one breaker	**B**	Standard: two breakers / breaker and a half
2	**Standard IEC 61850**			
	1	Not available.	**8**	IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy + 8 Goose Control Blocks.
	6	IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy.	**B**	8 + number of XSWI and CSWI logical nodes increased to 24 and 30 respectively
3	**User Interface**			
	S	Standard Model (Alphanumeric Display and Programmable Buttons)		
	G	S + Graphic Display		
4	**Power Supply Voltage**			
	1	24VDC/VAC (+-20%)	**3**	220 VDC/VAC (+-20%)
	2	48 - 250 VDC/VAC (+-20%)		
5	**Digital Inputs**			
	0	24 VDC	**3**	250 VDC
	1	48 VDC	**6**	125 VDC (activation >65%)
	2	125 VDC	**7**	250 VDC (Von=158VDC / Voff = 132VDC)
6	**Communication Interfaces [COM1-LOC] [COM 2-REMP1] [COM3-REMP2] [COM4-REMP3] [COM5-REMP4]**			
	0	[RS232 + USB] [--] [--] [--] [ELECTRIC CAN]	**C**	[RS232 + USB] [DOUBLE RING PFO] [DOUBLE RING PFO] [RS232/RS485] [ELECTRIC CAN]
	2	[RS232 + USB] [GFO ST] [GFO ST] [--] [ELECTRIC CAN]	**D**	[RS232 + USB] [ETHERNET] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]
	4	[RS232 + USB] [PFO] [PFO] [ELECTRIC CAN]	**E**	[RS232 + USB] [ETHERNET] [GFO ST] [RS232/RS485] [ELECTRIC CAN]
	7	[RS232 + USB] [RS232 F.M] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]	**F**	[RS232 + USB] [ETHERNET] [ETHERNET] [RS232/RS485] [ELECTRIC CAN]
	8	[RS232 + USB] [GFO ST] [GFO ST] [RS232/RS485] [ELECTRIC CAN]	**G**	[RS232 + USB] [RS232 F.M] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	9	[RS232 + USB] [GFO ST] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]	**H**	[RS232 + USB] [PFO] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	A	[RS232 + USB] [PFO] [GFO ST] [GFO ST] [ELECTRIC CAN]	**I**	[RS232 + USB] [GFO ST] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	B	[RS232 + USB] [PFO] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]		
	All options are compatible with IEC61850 PORTS			
7	**IEC 61850 Communications Ports (with support for PROCOME communication over ETHERNET)**			
	0	None	**3***	Two 100BASE-FX Connectors (Multimode GFO LC)
	1*	Two 100BASE-TX Connectors (RJ45)	**4***	One 100BASE-TX Connector (RJ 45) + One 100BASE-FX Connector (Multimode GFO LC)
	2*	Two 100BASE-FX Connectors (Multimode GFO ST)		
	(*) Includes USB FRONT PORT for CID download			

6IRV												
	1	2	3	4	5	6	7	8	9	10	11	12

Digit	Code	Description	Code	Description
8	**Inputs / Outputs**			
	3	44DI + 18DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2.5mA) + 16 LEDs.	**A**	25DI + 31 DO + 1 Alarm Output + 16 LEDs.
	4	63DI + 24DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2.5mA) + 16 LEDs.	**B**	37DI + 44 DO + 1 Alarm Output + 16 LEDs.
	5	82DI + 30DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2.5mA) + 16 LEDs.	**C**	49DI + 57 DO + 1 Alarm Output + 16 LEDs.
	7	44DI + 18DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (4-20mA) + 16 LEDs.	**D**	54DI + 50DO + 1 Alarm Output + 2 Input Transducers (4-20mA) + 16 LEDs.
	8	63DI + 24DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (4-20mA) + 16 LEDs.	**E**	80DI + 30DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 4 Input Transducers (4-20mA) + 16 LEDs.
	9	82DI + 30DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (4-20mA) + 16 LEDs.	**F**	59DI + 24DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 6 Input Transducers (4-20mA) + 16 LEDs.
			G	25DI + 12DO + 2 Trip Outputs + 2 Close Outputs + 1 Alarm Output + 2 Input Transducers (4-20mA) + 4 LEDs.
9	**Spare (to be defined in the factory)**			
	0	Standard Model	**2**	1 + Improved 25 unit
	1	0 + Standard Model + IPOL based overcurrent unit	**3**	2 + Increased CT & VT ratio.
10	**Enclosure/Chassis**			
	S	3U x 19" 1 Rack (Inputs / Outputs type G)	**2**	4U x 19" 1 Rack with cover (Inputs / Outputs type 3, 7 and A)
	Q	4U x 19" 1 Rack (Inputs / Outputs type 3, 7 and A)	**4**	6U x 19" 1 Rack with cover (Inputs / Outputs type 4, 5, 8, 9, B, C, D, E and F)
	V	6U x 19" 1 Rack (Inputs / Outputs type 4, 5, 8, 9, B, C, D, E and F)		
11	**Protocols for Remote Communication**			
	K	Standard [PROCOME 3.0/DNP 3.0 (Profile v.2)/MODBUS RTU - SERIAL and over ETHERNET for Remote Ports 1, 2 & 3]	**N***	Standard plus Virtual I/O Protocol for Remote Ports 1 & 2 + [DNP3 and MODBUS RTU over the IEC61850 ports]
	M	Standard plus Virtual I/O Protocol for Remote Ports 1 & 2		
	(*) Not available when the selection in digit 2 (IEC 61850 Standard) is 1.			
12	**Finishing**			
	--	Horizontal Rack Mount + [O] Red / [I] Green.	**Q**	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + For both User Interfaces (with texts in english).
	A	Vertical Rack Mount + [O] Red / [I] Green.	**R**	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + Texts in Spanish/Portuguese (only for Models with graphic display).
	L	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green.	**S**	Vertical Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + For both User Interfaces (with texts in english).
	M	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green + Texts in English (only for Models with graphic display).	**T**	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + Texts in Spanish/Portuguese (only for Models with graphic display)+box with front IP51.
	N	Vertical Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green.		
	P	Vertical Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green + Texts in English (only for Models with graphic display).		

- **Functions**

79	Recloser.
25	Synchronism Check.
27	Phase Undervoltage.
59	Phase Overvoltage.
59N	Ground Overvoltage.
67	Phase Directional.
50	Phase Instantaneous Overcurrent.
51	Phase Time Overcurrent (inverse / definite).
67N	Ground Directional.
50N	Ground Instantaneous Overcurrent.
51N	Ground Time Overcurrent (inverse / definite).
67Q	Negative Sequence Directional.
50Q	Negative Sequence Instantaneous Overcurrent (I2).
51Q	Negative Sequence Time Overcurrent (inverse / definite) (I2).
67P	Positive Sequence Directional.
81M	Overfrequency.
81m	Underfrequency.
81D	Frequency Rate of Change.
49	Thermal Image.
46	Open Phase: I2/I1 (current unbalance).
50STUB	STUB Bus Protection.
50BF	Breaker Failure.
3	Switching Circuit Monitoring.
2	Pole Discordance Detection.
60VT	Fuse Failure Detector.
OSC	Oscillographic Recording.

1.5.2 Models replaced by others with Higher Functionality and not Available Options

6IRV												
	1	2	3	4	5	6	7	8	9	10	11	12

2	**Standard IEC 61850**			
	7	IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy	**9**	IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy + CID load by frontal port.
11	**Protocols for Remote Communication**			
	P*	Standard + Virtual I/O Protocol by Remote Ports 1 & 2 + [5 instances by the IEC61850 ports, 1 PROCOME and 4 configurable DNP3 or MODBUS]		
	(*) Just when the selection of the communication interfaces for IEC61850, digit 7, all options except 0 option. Only available with 6 option in 2 digit (Standard IEC61850).			

1.6 Installation and Commissioning

1.6.1 General

Improper handling of electrical equipment is extremely dangerous, therefore, only skilled and qualified personnel familiar with appropriate safety procedures and precautions should work with this equipment. Damage to equipment and injury to personnel can result when proper safety precautions are not followed.

The following general safety precautions are provided as a reminder:

- High magnitude voltages are present in Power Supply and metering circuits **even after equipment has been disconnected**.
- Equipment should be **solidly grounded** before handling or operating.
- **Under no circumstances should the operating limits of the equipment be exceeded** (voltage, current, etc.).
- The power supply voltage should be **disconnected from the equipment before extracting or inserting any module**; otherwise damage may result.

The tests defined next are those indicated for the start-up of a **6IRV** IED. They do not necessarily coincide with the final manufacturing tests to which each manufactured IED is subjected. The number, the type and the specific characteristics of the acceptance tests are model dependent.

1.6.2 Accuracy

The accuracy of the measuring instruments and test source signals (auxiliary power supply voltage, AC currents and AC voltages) is key in electrical testing. Therefore, the information specified in the Technical Data section (2.1) of this manual can only be reasonably verified with test equipment under normal reference conditions and with the tolerances indicated in the UNE 21-136 and IEC 255 standards in addition to using precision instruments.

It is extremely important that there be little or no distortion (<2%) in the test source signals as harmonics can affect internal measuring of the equipment. For example, distortions will affect this IED, made up of non-linear elements, differently from an AC ammeter, because the measurement is made differently in both cases.

It must be emphasized that the accuracy of the test will depend on the instruments used for measuring as well as the source signals used. Therefore, tests performed with secondary equipment should focus on operation verification and not on measuring accuracy.

1.6.3 Installation

- **Location**

The place where the equipment is installed must fulfill some minimum requirements, not only to guarantee correct operation and the maximum duration of useful life, but also to facilitate placing the unit in service and performing necessary maintenance. These minimum requirements are the following:

- Absence of dust
- Absence of humidity
- Absence of vibration
- Good lighting
- Easy access
- Horizontal or vertical mounting

Installation should be accomplished in accordance with the dimension diagrams.

- **Connections**

The first terminal of the terminal block corresponding to the auxiliary power supply must be connected to ground so that the filter circuits can operate. The cable used for this connection should be 14 AWG stranded wire, with a minimum cross section of 2.5 mm^2. The length of the connection to ground should be as short as possible, but not more than 75 inches (30 cm). In addition, the ground terminal of the case, located on the rear of the unit, should be connected to ground.

1.6.4 Preliminary Inspection

The following equipment aspects should be examined:

- The unit is in good physical condition, mechanical parts are securely attached and no assembly screws are missing.
- The unit model number and specifications agree with the equipment order.

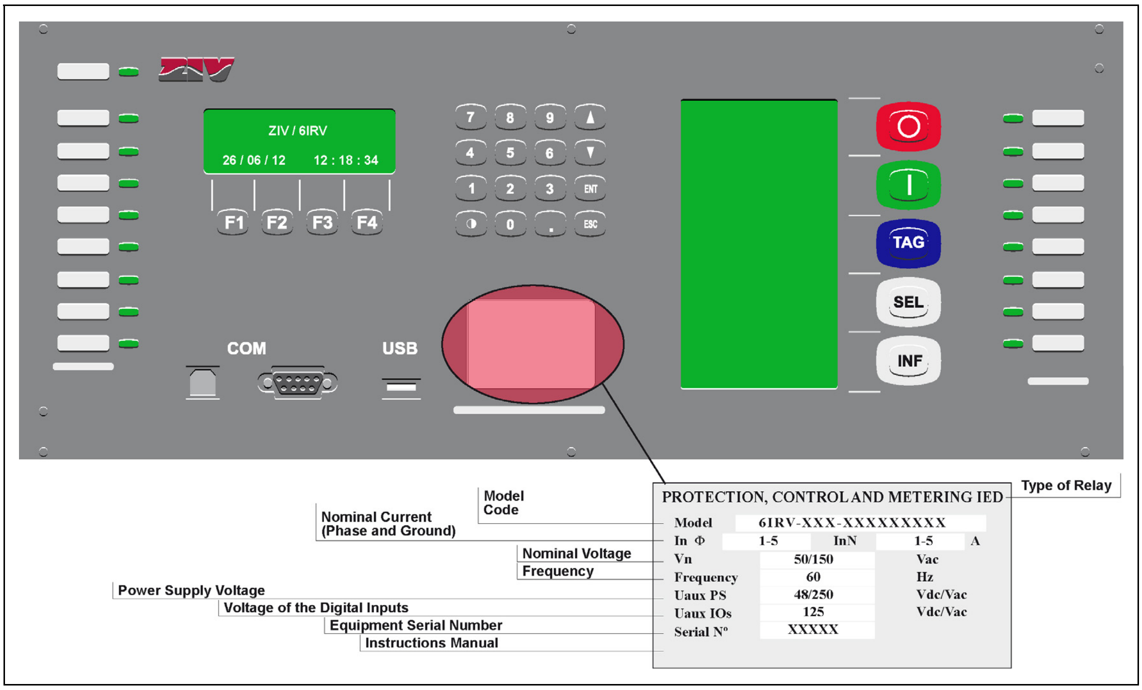


Figure 1.6.1 Name Plate.

1.6.5 Tests

1.6.5.a Isolation Test

While testing for isolation of switchgear and external wiring, the IED must be disconnected to avoid damage in case the test is not performed properly or if there are shorts in the harness, since the manufacturer has performed isolation testing on 100% of the units.

- **Common Mode**

All the terminals of the IED must be short-circuited, except those that relate to the power supply. The enclosure ground terminal must also be disconnected. Then 2000 Vac are applied between the interconnected terminals and the metal case for 1 min or 2500 Vac during 1s between the terminal group and the metal enclosure.

- **Between groups**

The isolation groups are made up of the current and voltage inputs (independent channels), digital inputs, auxiliary outputs, trip and close contacts and power supply. Refer to the connection's schematic to identify the terminals to group for performing the test. Then 2500 VAC are applied during 1 sec. between each pair of groups.

There are internal capacitors that can generate high voltage if the test points are removed for the insulation test without reducing the test voltage.

1.6.5.b Power Supply Test

Connect the power supply as indicated in following table.

VDC PROT	CON1P	CON2P
F3(+) - F2(-)	F4-F5	F4-F6

It is important to verify that, when the IED is not energized, the contacts designated CON2P in the table mentioned previously are closed, and those designated CON1P are open. Then it is fed its rated voltage and the contacts designated CON1P and CON2P must change state and the "In Service" LED must light up.

1.6.5.c Metering Tests

For this test it should be considered that, if it is required to avoid trips while this is being carried out, the elements should be disabled and the cutoff of the injection of current and/or voltage by the breaker avoided. Subsequently, the currents and voltages which, as an example, are indicated in the following table, will be applied to each of the channels and the following measures will be verified:

Applied Current or Voltage	Measured Current or Voltage	Phase of I or V applied	Phase of I or V measured	Freq. Applied (V > 20 Vac)	Freq. Measured (V > 20 Vac)
X	X ±1%	Y	Y ±1º	Z	Z ±5 mHz

Note: to check high current values, they are applied during the shortest possible time; for example, for 20 A, less than 8 seconds. To be able to view the angles, the phase A voltage must be applied the same as for measuring the frequency.

1.7 Onload Test

1.7.1 Introduction

The objectives of Onload Test are the following ones:

- Confirm that the external wiring of the voltage and current analog input channels is correct.
- Check the polarity of the current tranformers.
- Check the voltage and current measurements (module and angle).

In order to proceed with the test, primary injections will be done to check the polarity and transformation ratios. These tests can only be carried out if there are no restrictions related to the energization of the bay and all the other devices of the bay where the protection relay is located have already been commissioned.

Before starting the tests, check that all the test leads have been removed and ensure that the external wiring is properly connected (it is possible that during the commissioning tests external wirings have been disconnected).

1.7.2 Voltage Connections

Using a multimeter check that the secondary voltage measurements are correctly rated, and by means of a phase rotation meter confirm that the system phase rotation is the correct one.

Compare the secondary multimeter values with the measurements the relay shows in the measurement screen when the transformation ratio is set to 1. Check not only the module but also the angle. Modify the setting in order to show the measurements in primary values. The measurements that are displays in the HMI of the device or in the communication program should comply with the values which are specified in the Measurement Accuracy paragraph in Chapter 2.1, Technical Data.

1.7.3 Current Connections

Place a multimeter in series with each of the analog current inputs of the relay in order to test the secondary values of each phase. This test will be carried out comparing the value of the multimeter with the value displayed in the HMI of the relay when the transformation ratio is set to 1. Check not only the module but also the angle. Modify the setting in order to show the measurements in primary values. The measurements that are displays in the HMI of the device or in the communication program should comply with the values which are specified in the Measurement Accuracy paragraph in Chapter 2.1, Technical Data.

Check that when inyecting a balanced system, the current which is flowing through the neutral circuit of the transformer is negligible.

Ensure the current polarity is the correct one measuring the phase angle between the current and the voltage which are being injected.

Check that for load current flowing outside the bay (forward direction) the active power measurement is positive while for load current flowing inside the bay (reverse direction) the active power measurement is negative.

In those models with ground differential current measurement, check that the current polarity of the polarization channels is the correct one. Inject the same current value in the polarization channel and just in one phase analog input lagging 180º and check that the ground differential current (IGN) is zero or almost zero. In case of having ground differential current, modify the wiring of the polarization channel.

Chapter 2.

Technical Specifications and Physical Description

2.1 Technical Data

2.1.1 Power Supply Voltage

IEDs have two types of auxiliary power supplies. Depending on the model, their values are selectable:

24 Vdc (+20% / -15%)
48 - 250 Vdc/Vac (±20%)

Note: In case of power supply failure, a maximum interruption of 100 ms is allowed for 110 Vdc input.

2.1.2 Power Supply Burden

Quiescent	**7 W**
Maximum	**<12 W**

2.1.3 Current Analog Inputs

Nominal value	**In** = **5 A** or **1 A** (selectable in the IED)
Thermal withstand capability	**5 A** (continuously)
	62.5 A (for 3 s)
Dynamic limit	**300 A**
Current circuit burden	**<0.05 VA** (In = 1 A or 20 mA)

2.1.4 Voltage Analog Inputs

Nominal value	**Un** = **50** to **230 Vac**
Thermal withstand capability	**300 Vac** (continuously)
	600 Vac (for 10s)
Voltage circuit burden	**0.55 VA** (110/120 Vac)

2.1.5 Frequency

Operating range	**16 - 81 Hz**

2.1.6 Measurement Accuracy

Measured currents	**±0.1%** or **±2 mA** (the greater)
Phase and Ground	for In = 1A and 5A
Calculated currents	
Phase - Phase	**±0.2%** or **±6 mA** (the greater)
I_1, I_2 and I_0	**±0.3%** or **±8 mA** (the greater)
	for In = 1A and 5A
Measured voltages	**±0.1%** or **±50 mV** (the greater)
Phase-Ground, Phase-Phase, Ground and Synchronism	
Calculated voltages	
Phase-Phase (0 to 300V)	**±0.2%** or **±75 mV** (the greater)
VGround, V_1, V_2 and V_0	**±0.3%** or **±100 mV** (the greater)
Active and reactive powers (In = 5A and I_{phase}>1A)	
Angles 0º or ±90º or 180º	**±0.33% W/var**
Angles ±45º or ±135º	**±1.6% W/var**
Angles ±75º / ±115º	**±5% W / ±0.65 % var**
Angles	**±0.5º**
Power factor	**±0.013**
Frequency	**±0.005 Hz**

Note: signal processing

Sampling function adjustment of analog input signals is made by means of zero pass count of one of the measured signals, and works detecting the change in said signal period. The value of the calculated frequency is used to modify the sampling frequency used by the metering device attaining a constant sampling frequency of 32 samples per cycle. The frequency value is saved for later use in Protection and Control tasks.

Zero crossing is detected by the voltage channel VA or VAB. When VA phase voltage falls below 2 volts is not possible to measure frequency. In case of loosing phase voltage the unit operates as follows:

- **If the measured phase voltage is equal or larger than 2V for VB or VC, the last sampling frequency is kept.**
- **If all phase voltages are below 2V, the rated frequency is used as the sampling frequency.**

When Protection and Control tasks are readjusted in accordance with the sampling function, phasor real and imaginary components of analog signals are calculated by means of the Fourier transform. Fourier components are calculated by means of said Discrete Fourier Transform (DFT) using 32 sample/cycle. Using DFT this way the magnitude and phase angle of the fundamental component at power system frequency of every analog input signal is obtained. The rest of measurements and calculations of Protection functions is obtained based on the fundamental components calculated by the Fourier method. DFT gives a precise measurement of the fundamental frequency component and it is an efficient filter for harmonics and noise.

Harmonics are not completely damped for frequencies other than the nominal frequency. This is not a problem for small deviations of ±1Hz but, in order that a greater deviation from the working frequency can be allowed, the above-mentioned automatic adjustment of the sampling frequency is included. On lack of an adequate signal for sampling frequency adjustment, said frequency is adjusted to the corresponding nominal frequency (50/60Hz).

Angles reference for all the measurements displayed on the device corresponds to the channel VA.

2.1.7 Accuracy of the Pickup and Reset of the Overcurrent Elements

Overcurrent Units	
Pickups and resettings of Phase, Ground and Negative Sequence (for In = 1A and 5A) (Static Test)	**±3 %** or **±10mA** of the theoretical value (the greater)

Measuring times	
Fixed Time	**±1%** of the setting or **±35 ms** (the greater)
Inverse Time	**Class 2 (E=2)** or **±35 ms** (the greater) (UNE 21-136, IEC 255-4) (for measured currents of 100 mA or greater)

2.1.8 Accuracy of the Pickup and Reset of the Voltage Units

Overvoltage and Undervoltage Elements	
Pickup and reset (Static Test)	**±2 %** or **±250 mV** of the the theoretical value (the greater)
Measuring times	
Fixed Time	**±1%** of the setting or **±35 ms** (the greater)

2.1.9 Accuracy of the Pickup and Reset of the Frequency Elements

Overfrequency Elements	
Pickup and reset	**±0.01 Hz** of the theoretical value
Underfrequency Elements	
Pickup and reset	**±0.01 Hz** of the theoretical value
Measuring times	
Fixed Time	**±1%** of the setting or **±25 ms** (the greater)

2.1.10 Repeatability

Operating time	**2 %** or **25 ms** (the greater)

2.1.11 Transient Overreach

Expressed as: $ST = \frac{I_A - I_T}{I_A} x100$

<5%

I_A = Pick up value for a current with no dc component.
I_T = Pick up value for a current with maximum dc offset.

2.1.12 Digital Inputs

Configurable inputs with polarity (IN1 is alternating current, the rest are direct current).

Rated Voltage	Maximum Voltage	Burden	V on	V off
110/125 Vac	250 Vac	350 mW	90 Vac	46 Vac
24 Vdc	48 Vdc	50 mW	12 Vdc	9 Vdc
48 Vdc	90 Vdc	500 mW	30 Vdc	25 Vdc
125 Vdc	300 Vdc	800 mW	75 Vdc	60 Vdc
125 Vdc (Act.>65%)	300 Vdc	800 mW	93 Vdc	83 Vdc
250 Vdc	500 Vdc	1 W	130 Vdc	96 Vdc

IN3 to IN8 inputs can be programmed to monitor the switching circuits, and two different ranges are available

For IEDs with 24 Vdc digital inputs: monitoring voltage of **24 Vdc**
For IEDs with 48 Vdc, 125 Vdc or **250 Vdc digital inputs**: monitoring voltage of **48 Vdc** to **250 Vdc.**

Note: digital input IN1, with an AC supply, has an approximated activation and deactivation time of 150 ms.

2.1.13 Breaker Trip and Close Outputs and Auxiliary Outputs

2 contacts normally open for each switching, one of them internally configurable to closed and 6 or 12 (depending on the model) auxiliary contacts, generally open.

I DC maximum limit (with resistive load)	**60 A** (1 s)
I DC continuous service (with resistive load)	**16 A**
Close	**5000 W**
Breaking capability (with resistive load)	**240 W** - Max. 5 A - (48 Vdc)
	110 W (80 Vdc - 250 Vdc)
	2500 VA
Break (L/R = 0.04 s)	**120 W** at 125 Vdc
Switching voltage	**250 Vdc**
Momentary close time trip contacts remain closed	**100 ms**
Break delay	**<150 ms**

2.1.14 Input Transducers

0-5mA and ±2.5mA input transducers	
Input impedance	**511 Ω**
Measurement accuracy	**±0.2 %** or **±3 μA** (the greater)
4-20 mA input transducers	
Input impedance	**220 Ω**
Measurement accuracy	**±0.2 %** or **±3 μA** (the greater)
Voltage transducers (power supply monitoring for 125Vdc and 250 Vdc)	
Measurement accuracy (70Vdc to 350Vdc)	**±0.2 %** or **±0.5 V** (the greater)
Voltage transducers (power supply monitoring for 24Vdc and 48 Vdc)	
Measurement accuracy (10Vdc to 70Vdc)	**±0.2 %** or **±0.2 V** (the greater)

2.1.15 Communications Link

Local Communications Port (RS232C and USB).
Remote Communications Ports (GFO, PFO, RS232C, RS232-Full MODEM, RS485, ETHERNET and ELECTRIC CAN).
LAN (RJ45) Ports.
Electric Bus.

Glass Fiber Optics (Remote ports)	
Type	**Multimode**
Wavelength	**820 nm**
Connector	**ST**
Transmitter Minimum Power	
50/125 Fiber	**- 20 dBm**
62.5/125 Fiber	**- 17 dBm**
100/140 Fiber	**- 7 dBm**
Receiver Sensitivity	**- 25.4 dBm**

Glass Fiber Optics (LAN Ports)	
Type	**Multimode**
Wavelength	**1300 nm**
Connector	**MT-RJ**
Transmitter Minimum Power	
50/125 Fiber	**- 23.5 dBm**
62.5/125 Fiber	**- 20 dBm**
Receiver Sensitivity	**- 34.5 dBm**

Plastic Fiber Optics (1 mm)	
Wavelength	**660 nm**
Transmitter Minimum Power	**- 16 dBm**
Receiver Sensitivity	**- 39 dBm**

RS232C Port Signals	
Terminal unit DB-9 (9-pin) connectors	**Pin 5 - GND**
	Pin 2 - RXD
	Pin 3 - TXD

RS232C Full MODEM Port Signals	
Terminal unit DB-9 (9-pin) connectors	**Pin 1 - DCD**
	Pin 2 - RXD
	Pin 3 - TXD
	Pin 4 - DTR
	Pin 5 - GND
	Pin 6 - DSR
	Pin 7 - RTS
	Pin 8 - CTS
	Pin 9 - RI

RS485 Port Signals

Used signals	**Pin 4 - (A) TX+ / RX+** **Pin 6 - (B) TX- / RX-**

RJ45 Port Signals

Used signals	**Pin 1 - TX+** **Pin 2 - TX-** **Pin 3 - RX+** **Pin 4 - N/C** **Pin 5 - N/C** **Pin 6 - RX-** **Pin 7 - N/C** **Pin 8 - N/C**

Electric Bus

Used signals	**Pin 1 - High** **Pin 2 - Low** **Pin 3 - GND**

IRIG-B 123 and 003	B: 100pps	
	1: Amplitude modulated wave	0: By pulse width
	2: 1kHz/1ms	0: Without carrier
	3: BCD, SBS	3: BCD, SBS

Type BNC connector	
Input impedance*	**41 Ω / 211 Ω / 600 Ω**
Default impedance	**211 Ω**
Maximum input voltage	**10 V**
Synchronization Accuracy	**± 1ms**

When the IED is receiving an IRIG-B signal for synchronization both Date and Time settings will not be available through the HMI.

It is possible to configure one of the auxiliary outputs to check the IRIG-B signal status. This output will remain active as long as the IRIG-B signal reception is correct.

6IRV devices are also designed to give an indication for both the loss and recovery of such IRIG-B signal by generating the particular event

(*) Internally selectable by manufacturer.

2.2 Standards and Type Tests

The equipment satisfies the standards indicated below. When not specified, the standard is UNE 21-136 (IEC-60255).

2.2.1 Insulation

Insulation Test (Dielectric Strength)	*IEC-60255-5*
Between all circuit terminals and ground	**2 kV**, **50/60 Hz**, for **1 min**; or **2.5 kV**, **50/60 Hz**, for **1s**
Between all circuit terminals	**2 kV**, **50/60 Hz**, for **1min**; or **2.5 kV**, **50/60 Hz**, for **1s**
Measurement of Insulation Resistance	*IEC-60255-5*
Common mode	**R** ≥ **100 MΩ** or **5μA**
Differential mode	**R** ≥ **100 kΩ** or **5mA**
Voltage Impulse Test	*IEC-60255-5* (*UNE 21-136-83/5*)
Common mode (analog inputs, DIs, AOs and PS)	**5 kV**; **1.2/50 μs**; **0.5 J**
Differential mode (AOs)	**1 kV**; **1.2/50 μs**
Differential mode (Power Supply)	**3 kV**; **1.2/50 μs**

2.2.2 Electromagnetic Compatibility

1 MHz Burst Test	*IEC-60255-22-1 Class III* (*UNE 21-136-92/22-1*)
Common mode	**2.5kV**
Differential mode	**2.5kV**
Fast Transient Disturbance Test	*IEC-60255-22-4 Class IV* (*UNE 21-136-92/22-4*) (**IEC 61000-4-4**) **4 kV ±10 %**
Radiated Electromagnetic Field Disturbance	*IEC 61000-4-3 Class III*
Amplitude modulated (*EN 50140*)	**10 V/m**
Pulse modulated (*EN 50204*)	**10 V/m**
Conducted Electromagnetic Field Disturbance	*IEC 61000-4-6 Class III* (*EN 50141*)
Amplitude modulated	**10 V**
Electrostatic Discharge	*IEC 60255-22-2 Class IV* (*UNE 21-136-92/22-2*) (*IEC 61000-4-2*)
On contacts	**±8 kV ±10 %**
In air	**±15 kV ±10 %**

Surge Immunity Test	*IEC-61000-4-5* (*UNE 61000-4-5*)
	(1.2/50µs - 8/20µs)
Between conductors	4 kV
Between conductors and ground	4 kV

Radiated Electromagnetic Field Disturbance at Industrial Frequency (50/60 Hz)	*IEC61000-4-8*

Radio Frequency Emissivity	*EN55022* (Radiated)
	EN55011 (Conducted)

2.2.3 Environmental Test

Temperature	*IEC 60068-2*
Cold work	*IEC 60068-2-1*
	-5º C, **2 hours**
Cold work limit conditions	*IEC 60068-2-1*
	-10º C, **2 hours**
Dry heat	*IEC 60068-2-2*
	+45º C, **2 hours**
Dry heat limit conditions	*IEC 60068-2-2*
	+55º C, **2 hours**
Humid heat	*IEC 60068-2-78*
	+40º C, **93% relative humidity**, **4 days**
Quick temperature changes	*IEC 60068-2-14 / IEC 61131-2*
	IED open,
	-25º C for **3h** and
	+70º C for **3h** (**5 cycles**)
Changes in humidity	*IEC 60068-2-30 / IEC 61131-2*
	+55º C for **12h** and
	+25º C for **12h** (**6 cycles**)
Endurance test	**+55º C** for **1000 hours**

Operating range	From **-40ºC** to **+85ºC** (standard model) From **-40ºC** to **+70ºC** (model with IEC61850 communications interface)
Storage range	From **-40ºC** to **+85ºC** (standard model) From **-40ºC** to **+70ºC** (model with IEC61850 communications interface)
Humidity	**95 %** (non-condensing)

Climate Test (55º, 99% humidity, 72 hours)

Time / Current Characteristic	*ANSI C37.60 Class II*

2.2.4 Power Supply

Power Supply Interference and Ripple	*IEC 60255-11 / UNE 21-136-83 (11)* **< 20 %** and **100 ms**
Inverse Polarity of the Power Supply	*IEC 61131-2*
Resistance of Ground Connection	*IEC 61131-2* **< 0.1 Ω**
Gradual Stop / Start Test	*IEC 61131-2 (Test A)*
Surge Capacity	*IEC 60044-1*

2.2.5 Mechanical Test

Vibration (sinusoidal)	*IEC-60255-21-1 Class I*
Mechanical Shock and Bump Test	*IEC-60255-21-2 Class I*
External Protection Levels	*IEC-60529 / IEC 60068-2-75*
Front	*IP31* (without protection cover) *IP51* (with protection cover)
Rear Protection	*IP10*
Mechanical Protection	*IK07*

The models comply with the EEC 89/336 standard of electromagnetic compatibility.

2.3 Physical Architecture

2.3.1 General

The equipments are made up of the following boards:

- Power supply.
- Processor module and analog inputs
- Digital inputs, outputs and transducers inputs.
- Communications module.

The boards, or modules, are mounted horizontally and can be extracted by removing the front panel. External connections use plug-in terminal blocks on the rear panel of the enclosure, with ring lug connectors.

Depending on the terminal configuration, all the contact inputs / outputs may be used or some may remain as spare signals.

Figures 2.3.1 and 2.3.2 represent the external appearance of the equipment.

Mounted on the front are the alphanumeric keypad and display, the local communication ports (RS232C and USB), the local control buttons and the LED targets.

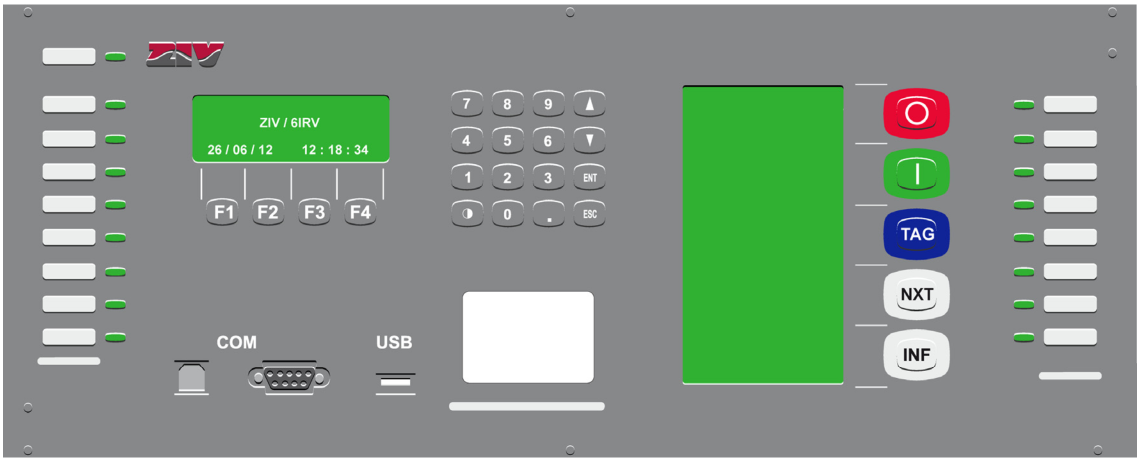


Figure 2.3.1 Front of a 6IRV.

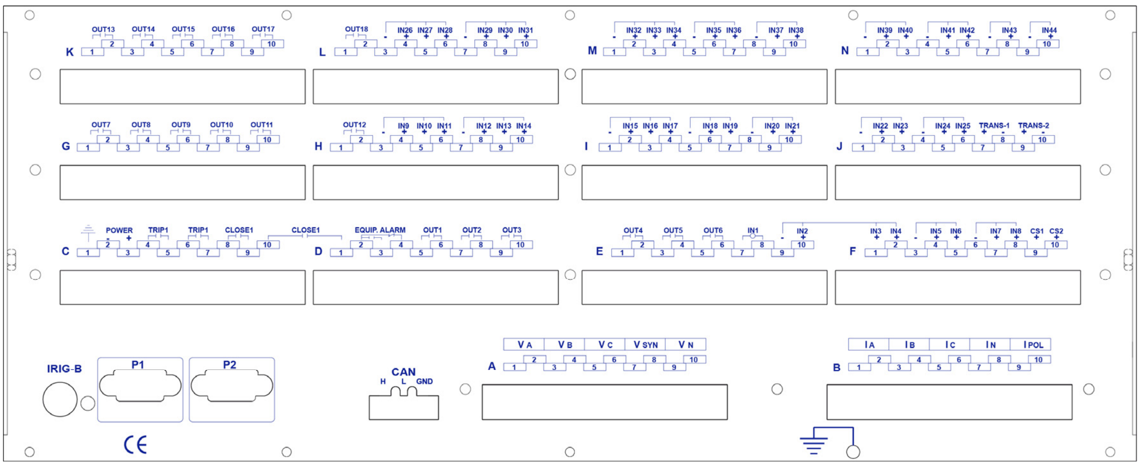


Figure 2.3.2 Rear of a 6IRV.

2.3.2 Dimensions

Depending on the model, **6IRV** relays are mounted as follows:

- Models in enclosures of 1 19"-, 4 standard units high.
- Models in enclosures of 1 19"-, 6 standard units high.

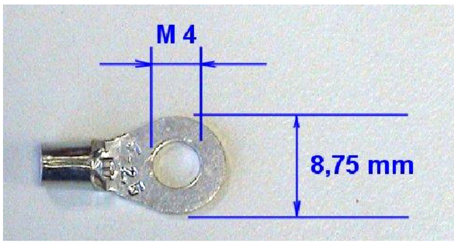
The equipment is intended to be installed either semi-flush mounted on panels or inside a 19” rack. The enclosure is graphite gray.

2.3.3 Connection Elements

2.3.3.a Terminal Blocks

The number of connectors depends on the number of the model's contact inputs and outputs. Moreover, the terminal blocks are arranged differently depending on the model (4-units or 6-units high).

The self-shorting ring lug terminals corresponding to the current / voltage analog inputs take wires up to #10 AWG (6 mm^2). We recommend ring lug terminals for these connections.



The connectors are plug-in and not self-shorting. They can be assigned to the current circuits supporting a current of 20 A continuously.

2.3.3.b Removing Printed Circuit Boards (Non Self-shorting)

WARNING!

The IED's printed circuit board can be taken out. **WARNING: the current connector is non self-shorting. Consequently, the CT secondaries must be short-circuited externally before board removal.**

The printed circuit board is attached to the case with self-tapping screws. These screws must be removed before the board is withdrawn. This operation always requires the protection to be **not in service**.

2.3.3.c Internal Wiring

The equipment uses traditional printed circuit board connections and internal buses to minimize internal wiring.

Chapter 3.

Functions and Description of Operation

3.1 Overcurrent Elements

Overcurrent protection elements
Three phase instantaneous overcurrent elements (50PH1, 50PH2 and 50PH3)
Three ground instantaneous overcurrent elements (50N1, 50N2 and 50N3)
Three negative sequence instantaneous overcurrent elements (50NS1, 50NS2 and 50NS3)
Three phase time overcurrent elements (51PH1, 51PH2 and 51PH3)
Three ground time overcurrent elements (51G1, 51G2 and 51G3)
Three negative sequence time overcurrent elements (51NS1, 51NS2 and 51NS3)

3.1.1 Phase, Ground and Negative Sequence Instantaneous Elements

Phase, ground, polarization current (**6IRV-***-*****1*** or higher models) and negative sequence instantaneous elements operate as a function of input current RMS value. Elements activate when RMS values exceed 1.05 times the pickup setting, and reset at 1 time the pickup setting.

Elements are provided with adjustable timers that allow for optional timing of instantaneous elements.

3.1.2 Phase, Ground and Negative Sequence Time Overcurrent Elements

In phase, ground and negative sequence time overcurrent elements, the time overcurrent element operates on the input current RMS value. Element picks up when the measured value exceeds 1.05 times the setting value, and resets at 1 time the setting value.

Element pickup enables the time delay function, which will make an integration of the measured values. This is carried out applying input current-dependent increments over a meter, the end of count of which governs the operation of the time overcurrent element.

Drop of the measured RMS value below the pickup setting value results in a quick integrator reset. For output activation, pickup must be active during the entire integration time; any integrator reset brings the integrator back to initial conditions, so that new activations start timing from zero.

Time characteristics can be selected among the various types of curves according to **IEC**, **IEEE** (Standard IEEE C37.112-1996) and **US** standards:

IEC CURVES

Inverse curve	Inverse curve + time limit
Very inverse curve	Very inverse curve + time limit
Extremely inverse curve	Extremely inverse curve + time limit
Long time inverse curve	Long time inverse curve + time limit
Short time inverse curve	Short time inverse curve + time limit

IEEE CURVES

Moderately inverse curve	Moderately inverse curve + time limit
Very inverse curve	Very inverse curve + time limit
Extremely inverse curve	Extremely inverse curve + time limit

US CURVES

Moderately inverse curve	Moderately inverse curve + time limit
Inverse curve	Inverse curve + time limit
Very inverse curve	Very inverse curve + time limit
Extremely inverse curve	Extremely inverse curve + time limit
Short time inverse curve	Short time inverse curve + time limit

The **RI Inverse Curve** may be added to the above curves, mainly used with electromechanical relays.

Time multiplier setting is the same as for **IEC**, **IEEE**, **US** and **RI Inverse** curves: range is 0.05 to 10 times.

Nevertheless, effective range for **IEC** curves is 0.05 to 1; for settings above 1, the maximum value of 1 is used. Effective range for the other curves (**IEEE**, **US** and **RI**) starts from 0.1 times; settings below this value operate as if they were set to the minimum value (0.1 times). Furthermore, although setting vary in steps of 0.01, the effective step for these three types of curve is 0.1; any setting other than a multiple of 0.1 will be rounded to the nearest tenth, namely, a setting of 2.37 will be applied as if it were 2.40 and a setting of 2.33 will be applied as if it were 2.30 (the setting 2.35 will be applied as if it were 2.40).

A **User-Defined** time characteristic may be added to the above characteristics, downloading it into the relay through the communications system. For inverse-time characteristics, delay time settings are composed of two values: **Curve Type** and **Time Multiplier** (**Dial**) within the family.

Curve types with **Time Limit** are regular time delayed functions with a time threshold, so that no trip takes place before the specified time. This results in that beyond a specified time the tripping curve turns into a horizontal straight line. This operate time limit coincides with the time setting used in the **Definite Time** option.

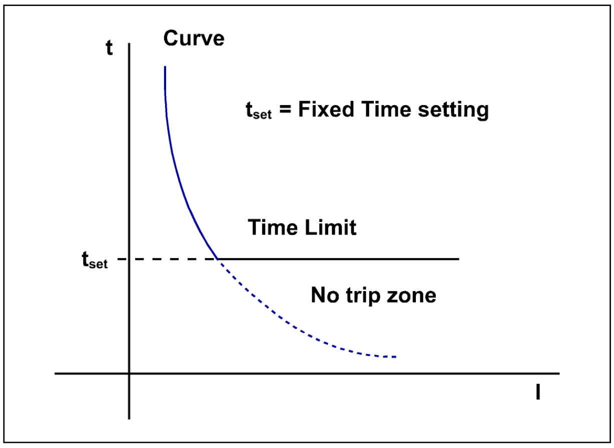


Figure 3.1.1 Diagram of a Curve with a Time Limit for a Time Overcurrent Element.

Definite Time setting range might be excessive compared with curve times. If this should be the case, if curve time (for the dial setting and a current 1.5 times greater than the setting) is less than the **Definite Time** setting, a time delay corresponding to 1.5 times the current is used as a limit line for element operation.

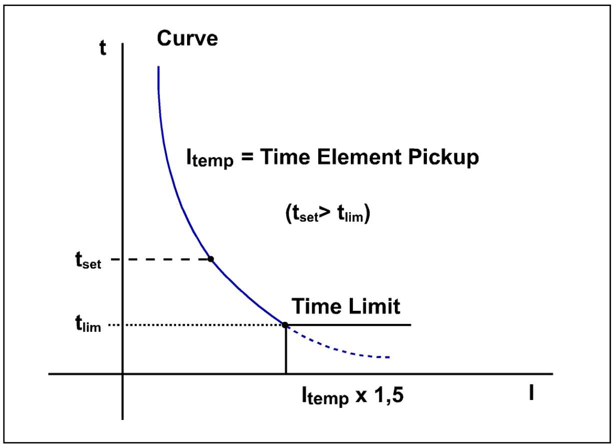


Figure 3.1.2 Time Limit of the Element when the Fixed Time is Greater than the Curve Time (in pickup x 1.5).

Note: it is worth highlighting that although curves are defined for an input value of up to 20 times the tap, which is the pickup setting of each of the time overcurrent elements, said range cannot always be guaranteed.

It is important to consider that the saturation limit of the current channels is 160A. Based on these limits, the "number of times the tap" for which the curves are effective depends on the setting:

- **If** $\frac{SaturationLimit}{ElementSetting} > 20$**, the curve is guaranteed to work for the element with this setting throughout its range of taps (up to 20 times the setting).**
- **If** $\frac{SaturationLimit}{ElementSetting} < 20$**, the curve is guaranteed to work for the element with this setting up to a number of times the tap equal to the value of this limit divided by the corresponding setting.**

When a current greater than 20 times the setting is injected, the trip time will be the same as that corresponding to these 20 times.

3.1.2.a Current / Time Curve: Inverse Functions

Figures 3.1.3, 3.1.4, 3.1.5, 3.1.6 and 3.1.7 present the inverse curves according to the IEC standards.

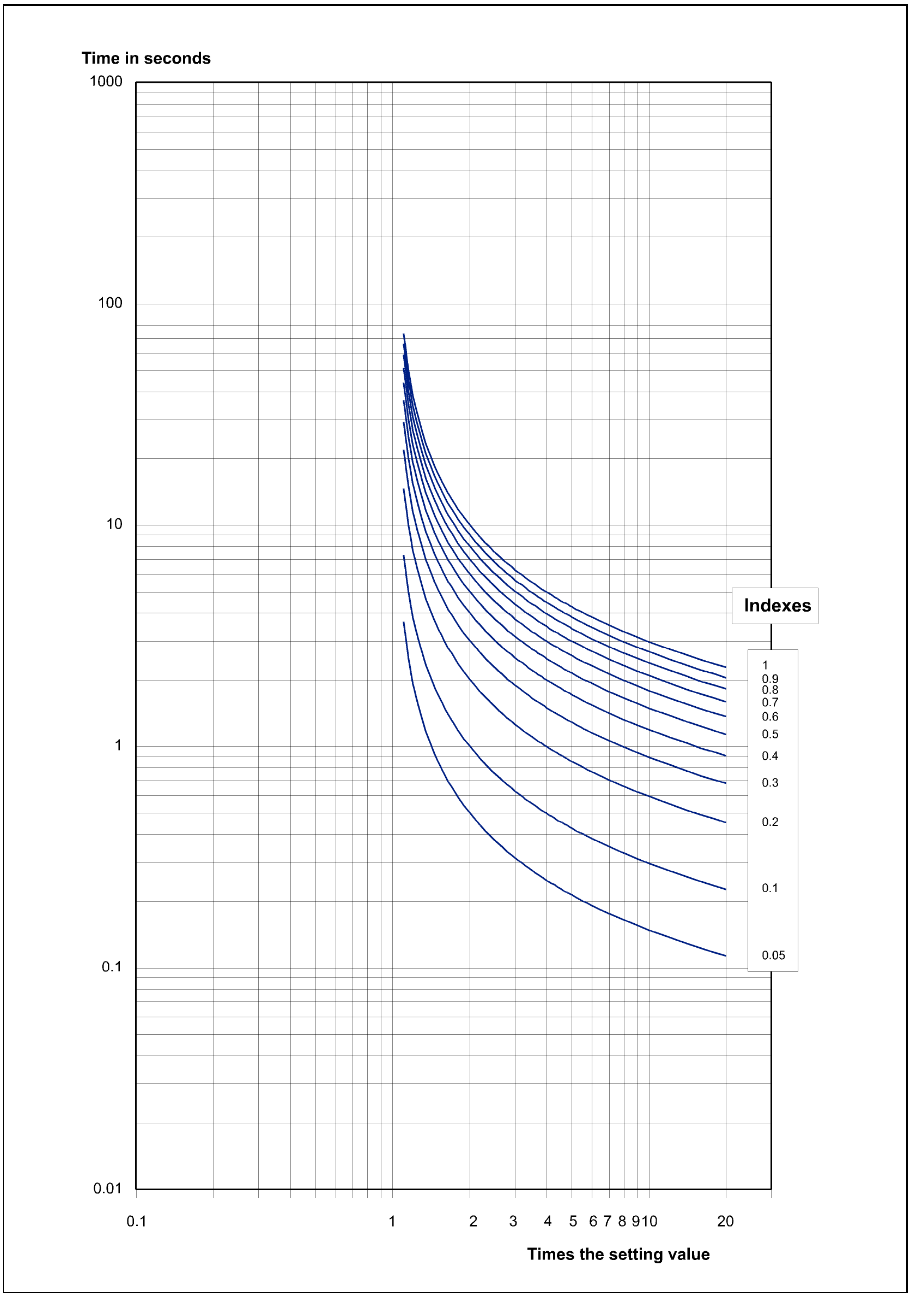


Figure 3.1.3 INVERSE Time Curve (IEC).

$t = \frac{0.14}{I_S^{\ 0.02} - 1} \times \text{Index}$	$I_S = \frac{I_{measured}}{I_{pickup}}$

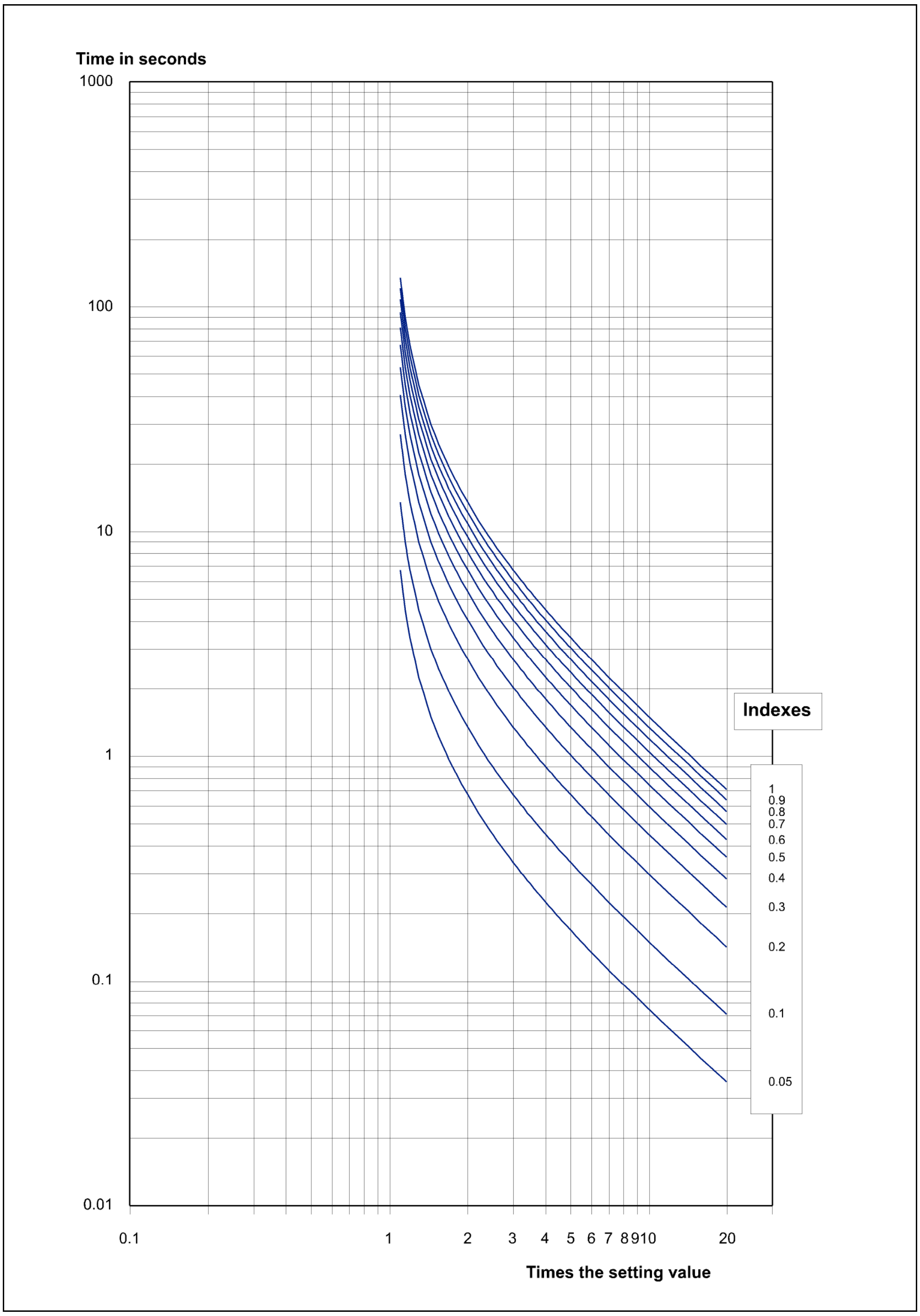


Figure 3.1.4 VERY INVERSE Time Curve (IEC).

$t = \frac{13.5}{I_S - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

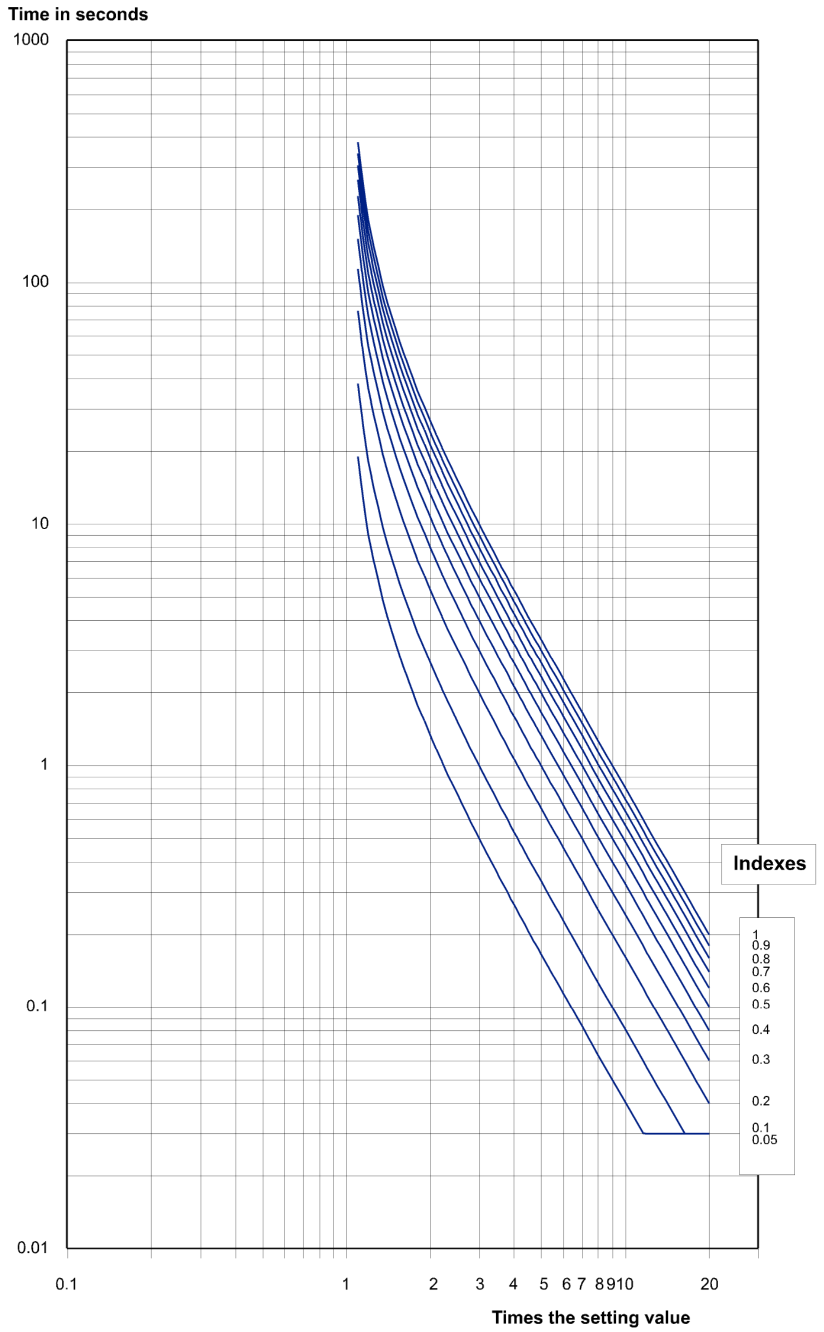


Figure 3.1.5 EXTREMELY INVERSE Time Curve (IEC).

$t = \frac{13.5}{I_S - 1}$ x Index	$I_S = \frac{I\ measured}{I\ pickup}$

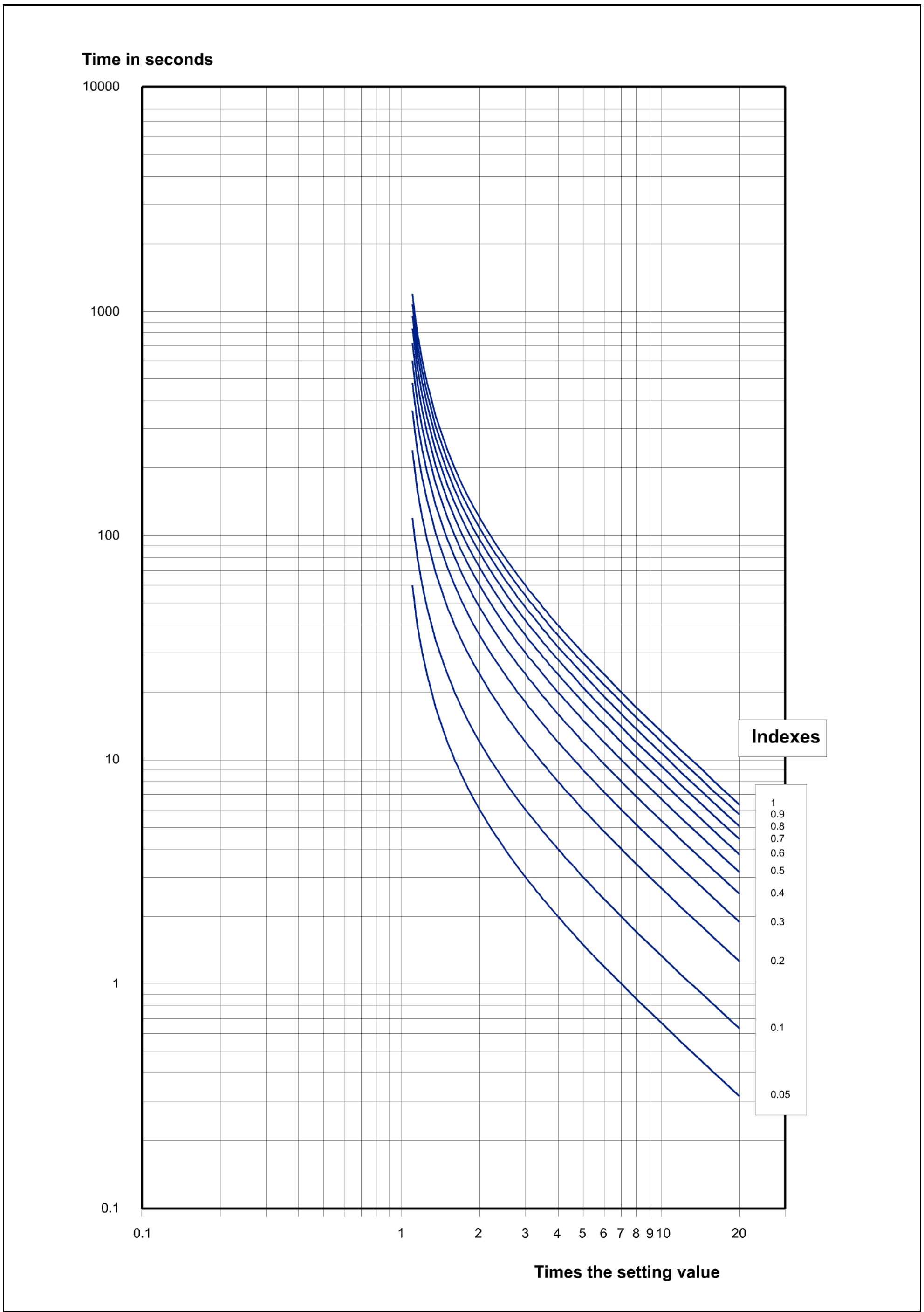


Figure 3.1.6 LONG TIME-INVERSE Curve (IEC).

$t = \frac{120}{I_S - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

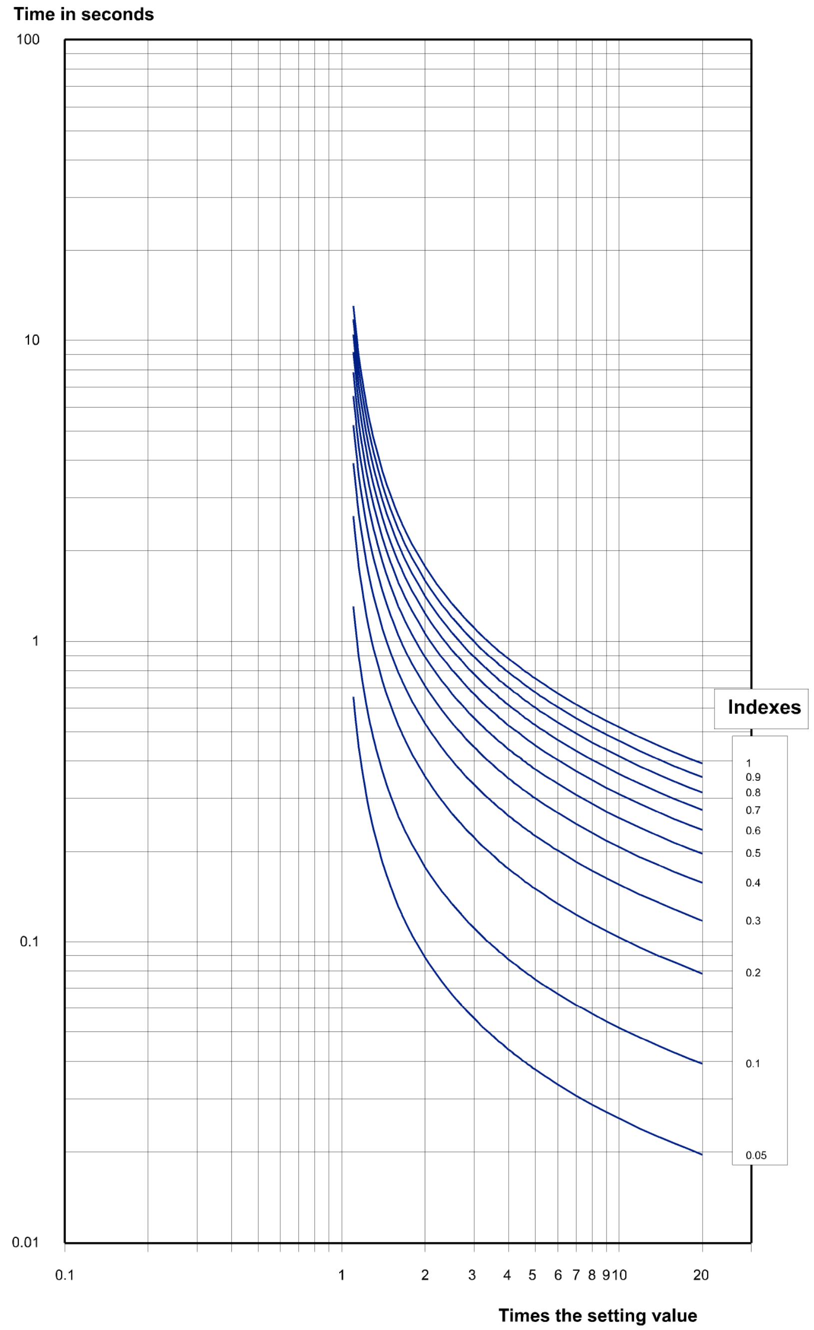


Figure 3.1.7 SHORT TIME-INVERSE Curve (IEC).

$t = \dfrac{0.05}{I_S^{0.04} - 1}$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

Figures 3.1.8, 3.1.9, 3.1.10, 3.1.11, 3.1.12, 3.1.13, 3.1.14 and 3.1.15 present the inverse curves according to the IEEE and US standards.

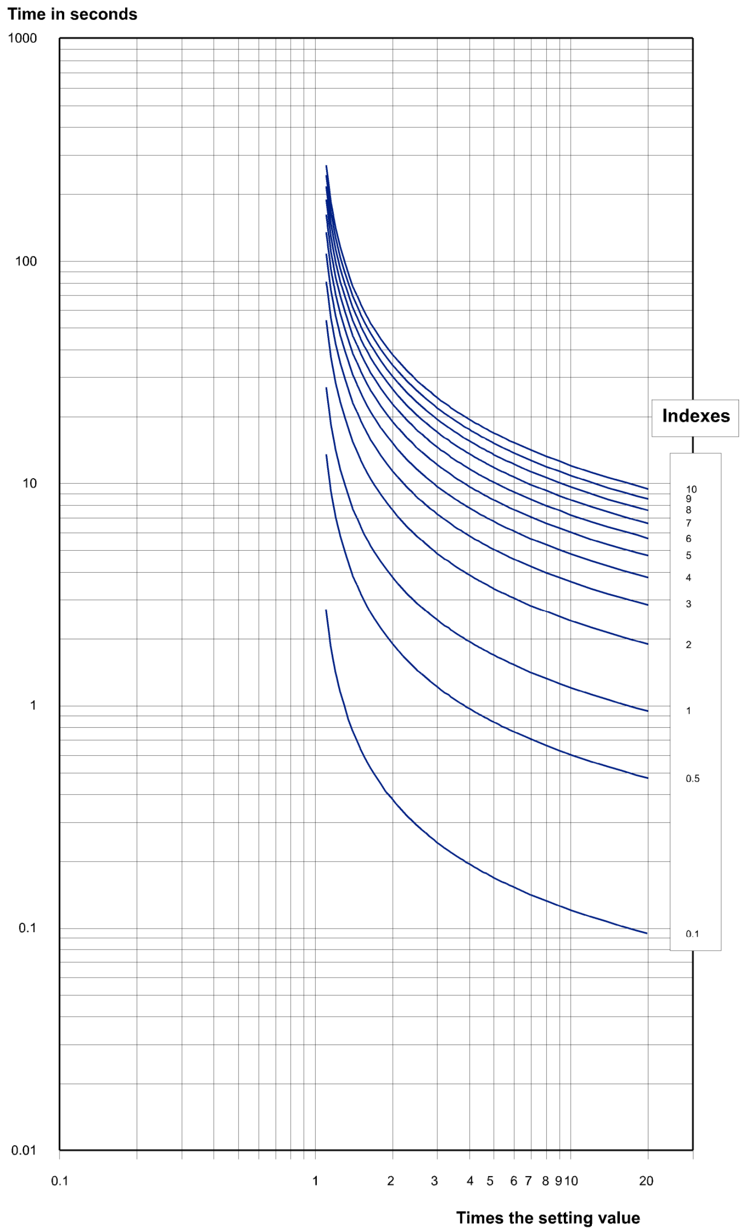


Figure 3.1.8 MODERATELY INVERSE Time Curve (IEEE).

$t = 0.114 + \dfrac{0.0515}{I_S^{0.02} - 1}$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

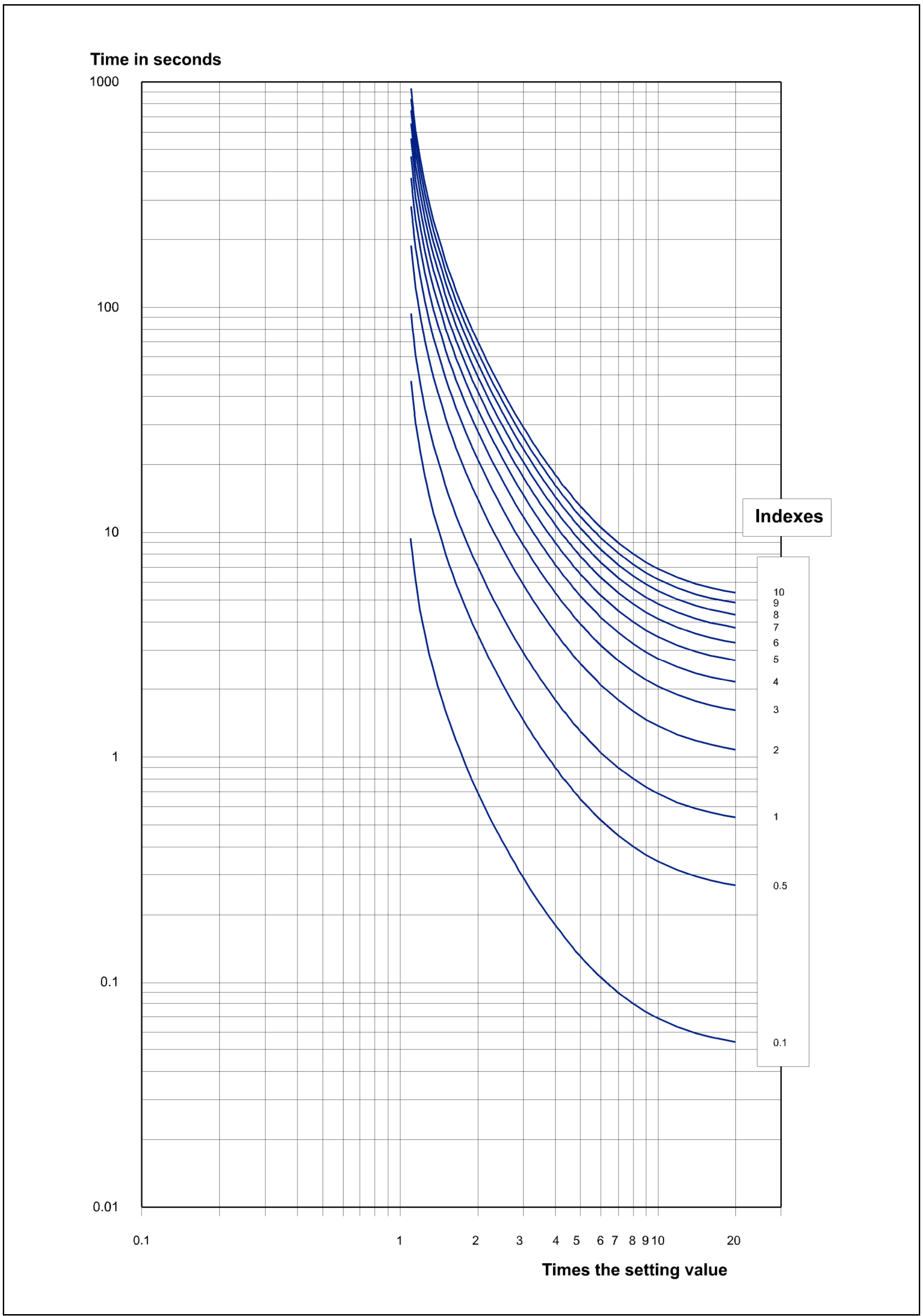


Figure 3.1.9 VERY INVERSE Time Curve (IEEE).

$t = 0.491 + \dfrac{19.61}{I_S^{\,2} - 1}$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

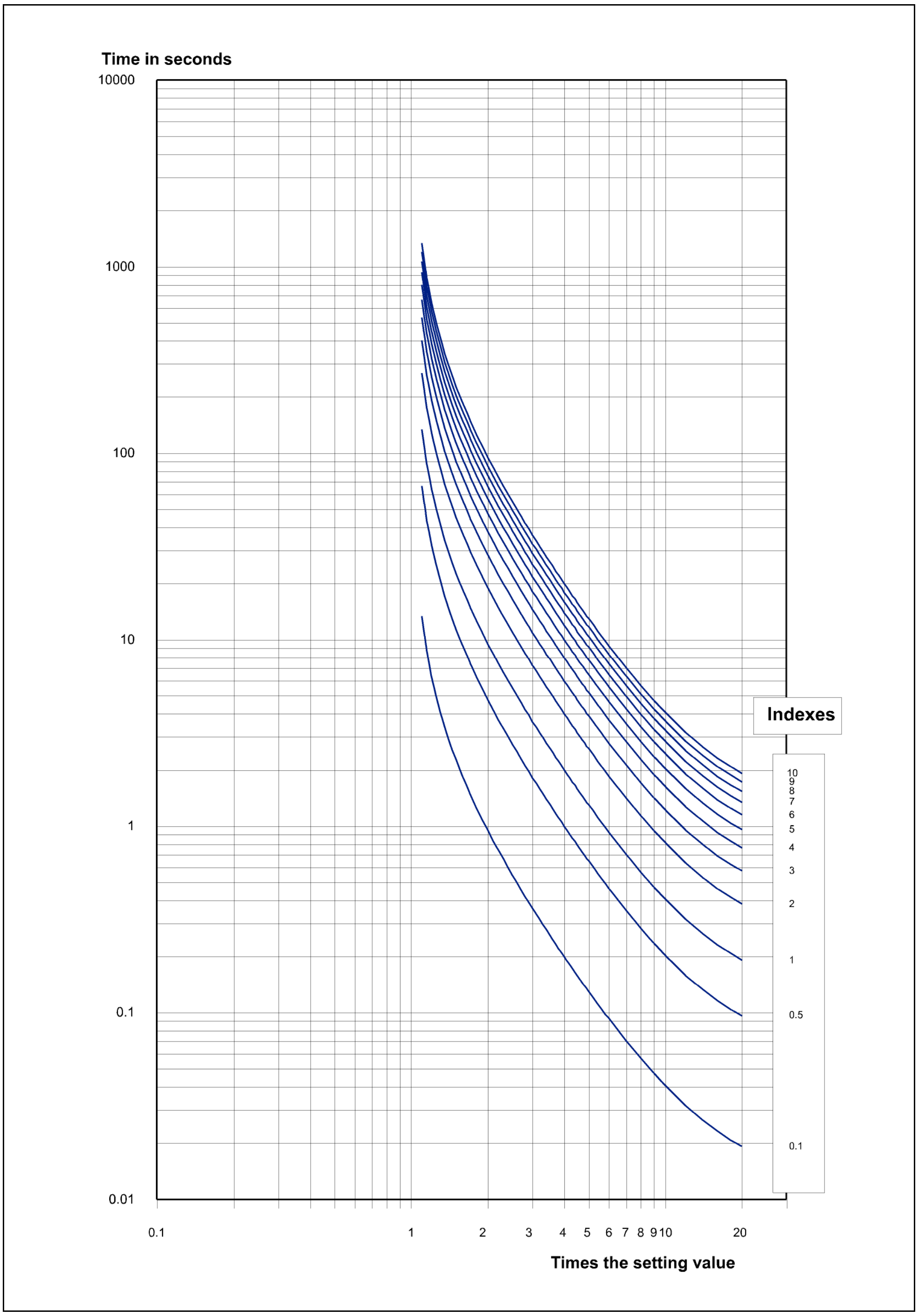


Figure 3.1.10 EXTREMELY INVERSE Time Curve (IEEE).

$t = 0.1217 + \frac{28.2}{I_S^{2} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

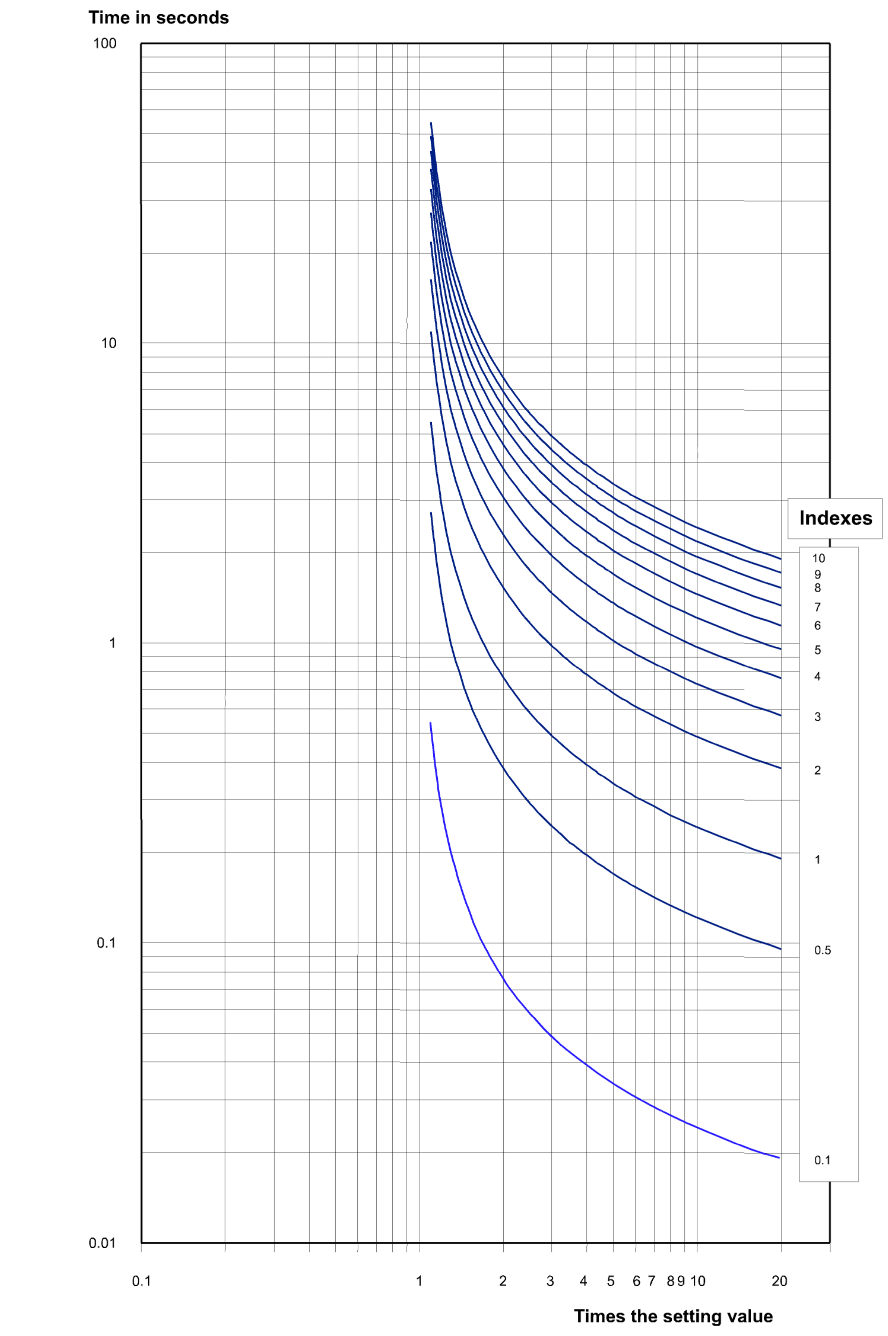


Figure 3.1.11 MODERATELY INVERSE Time Curve (U.S.).

$t = 0.0226 + \frac{0.0104}{I_S^{0.02} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

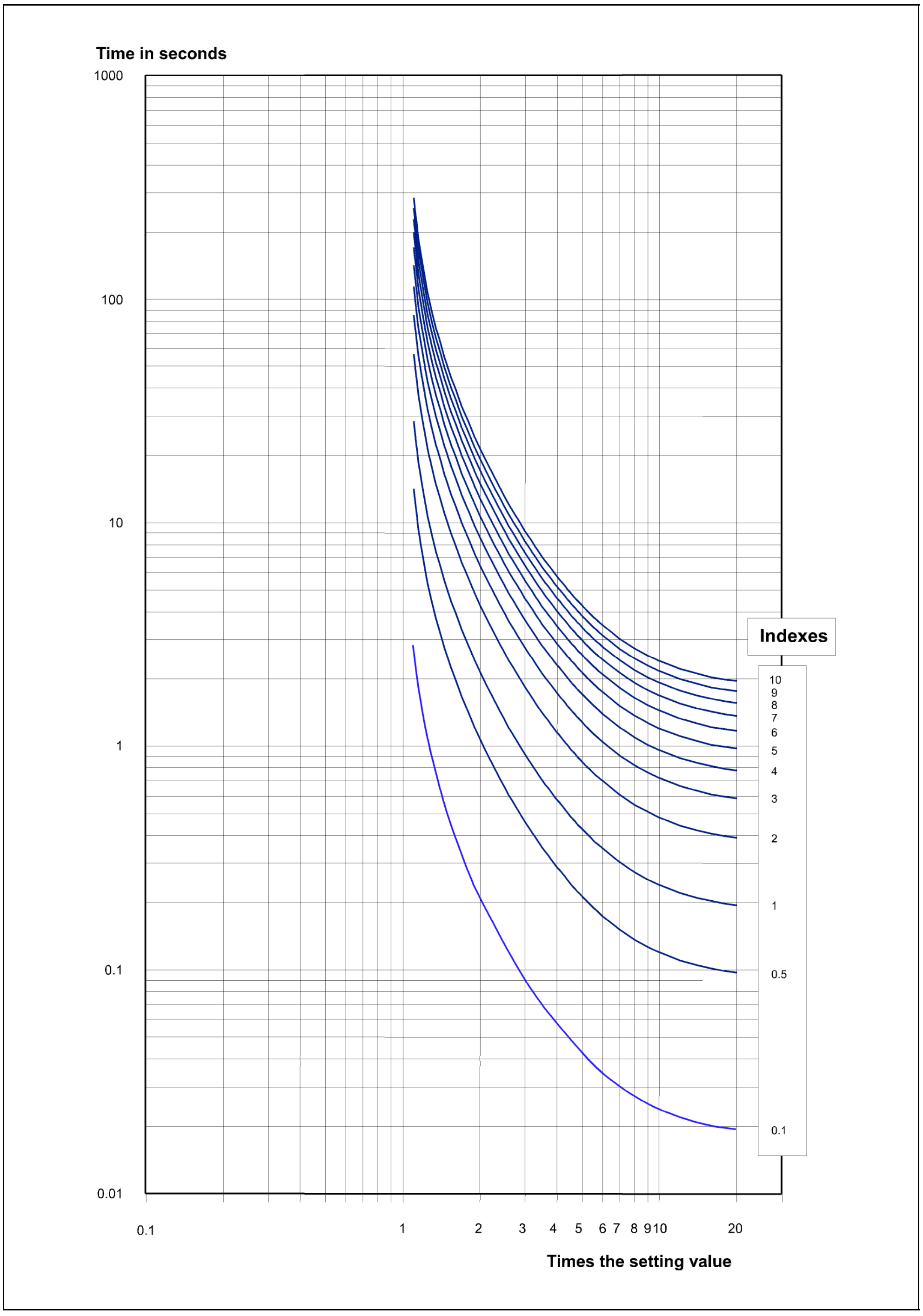


Figure 3.1.12 INVERSE Time Curve (U.S.).

$t = 0.180 + \frac{5.95}{I_S^2 - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

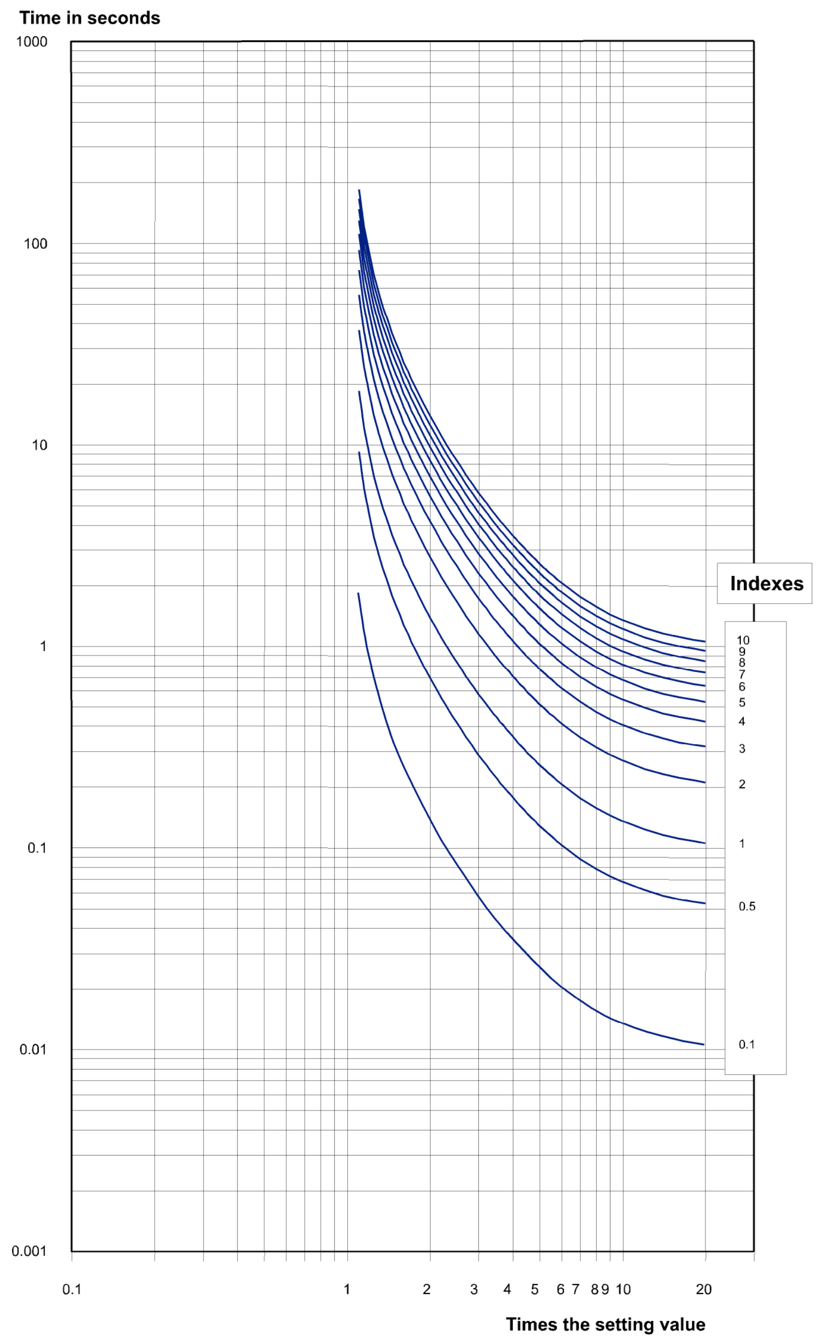


Figure 3.1.13 VERY INVERSE Time Curve (U.S.).

$t = 0.0963 + \frac{3.88}{I_S^2 - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

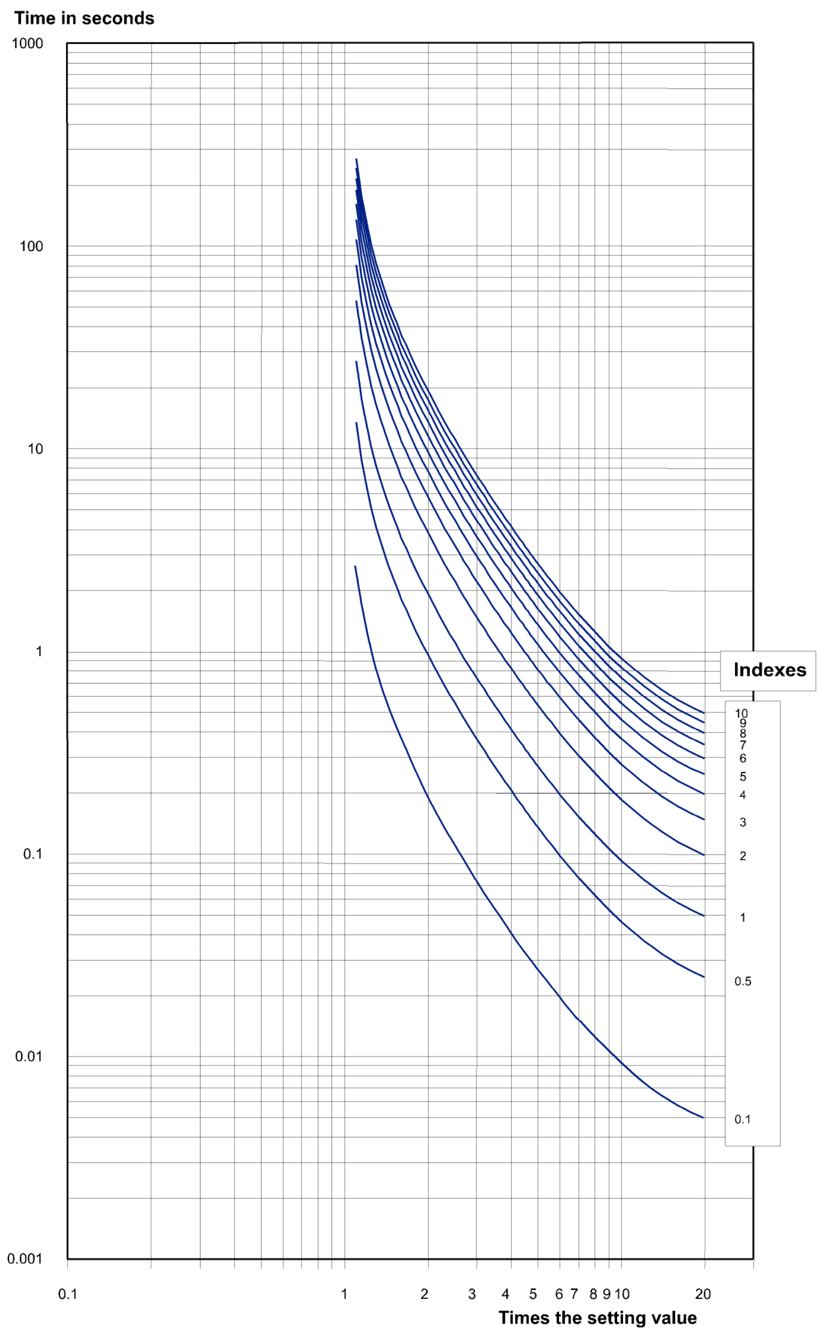


Figure 3.1.14 EXTREMELY INVERSE Time Curve (U.S.).

$t = (0.0352 + \frac{5.67}{I_S^2 - 1})$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

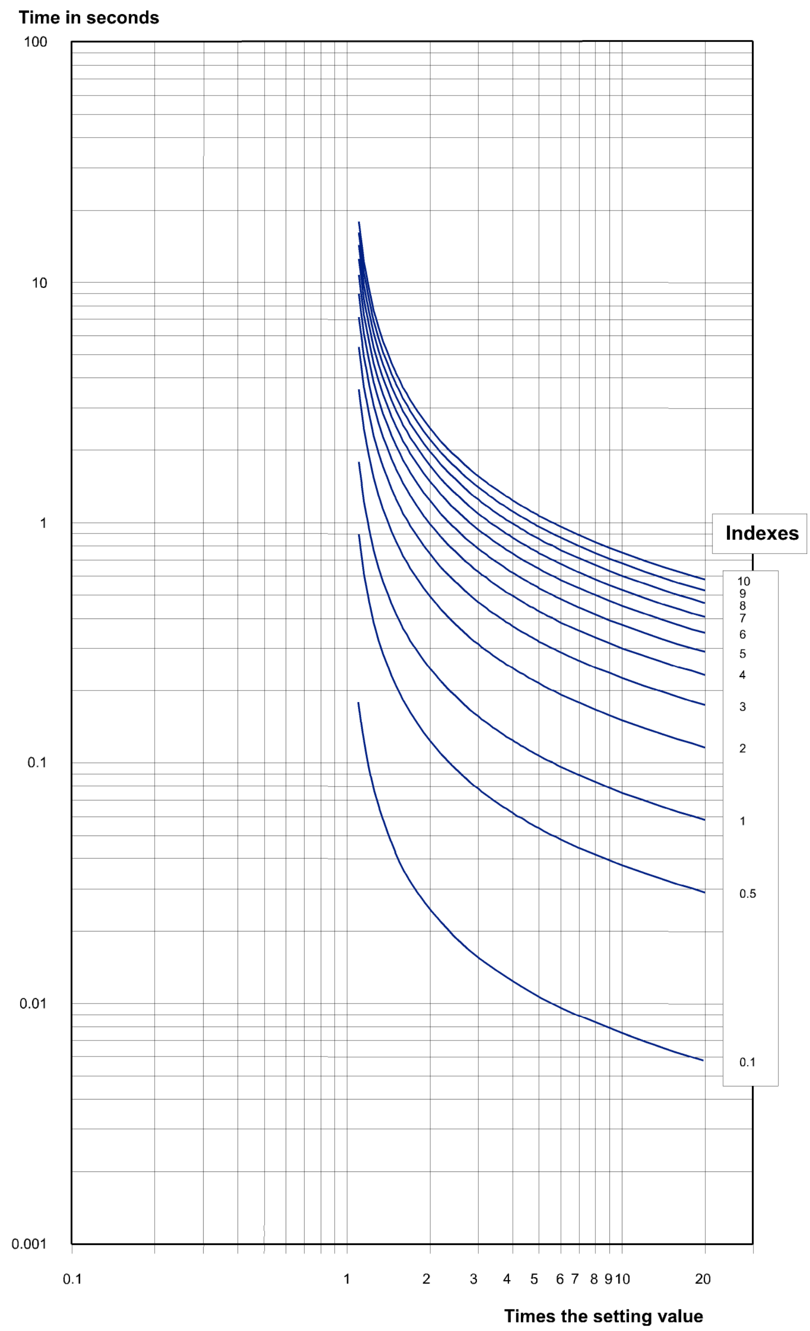


Figure 3.1.15 SHORT INVERSE Time Curve (U.S.).

$t = (0.00262 + \frac{0.00342}{I_S^{0.02} - 1})$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

And figure 3.1.16 presents the RI inverse curve.

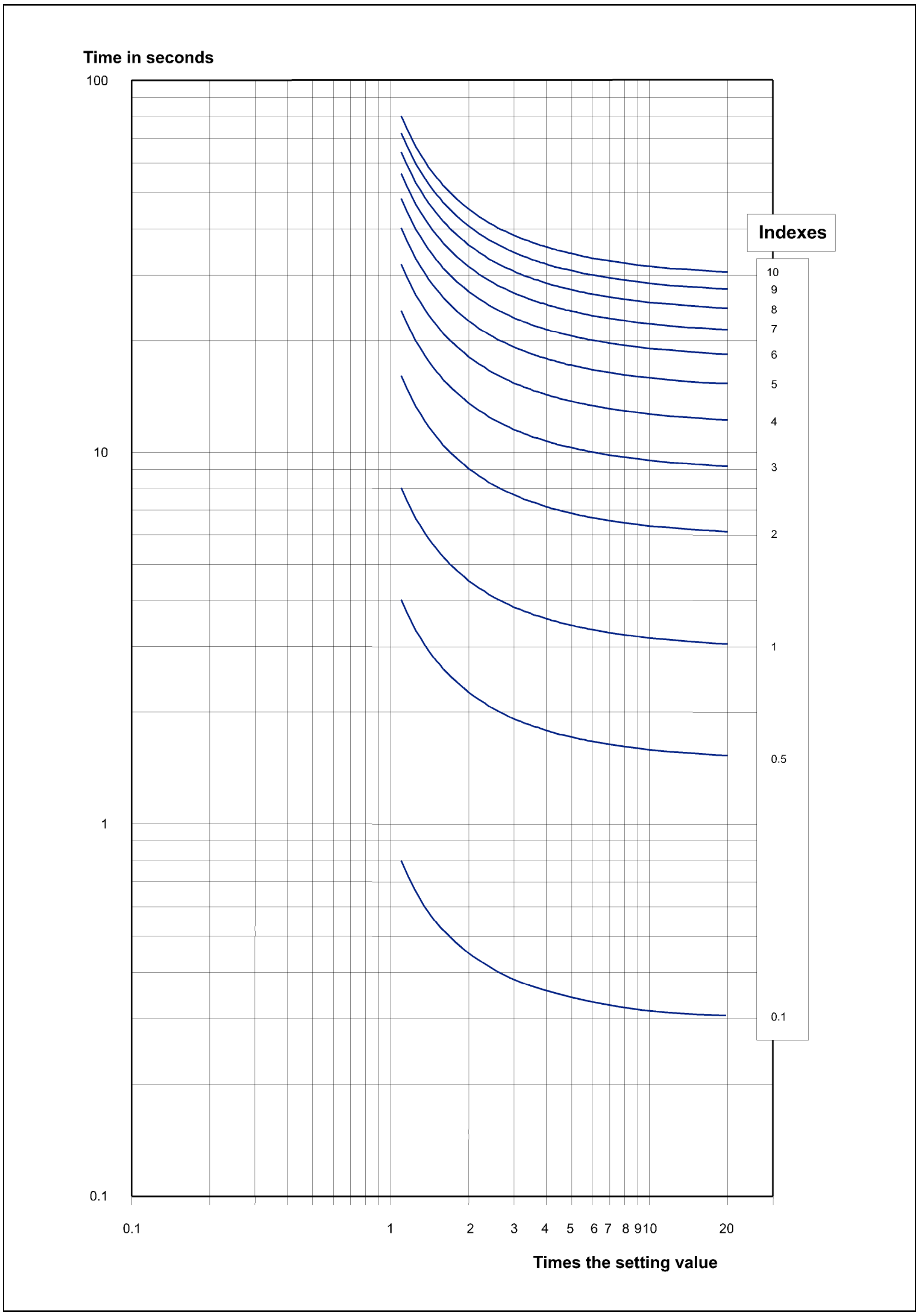


Figure 3.1.16 RI INVERSE Time Curve.

$t = \dfrac{1}{0.339 - 0.236 \cdot \left(\dfrac{1}{I_S}\right)}$ x Index	$I_S = \dfrac{I\ measured}{I\ pickup}$

3.1.3 Torque Control

The **Torque Control** setting associated with an overcurrent unit allows selecting the directionality of this unit. Possible setting values are:

0 - There is no permission to use directionality.
1 - Permission to use the indications in the co-direction current.
2 - Permission to use the indications in the reverse current.

An element with **Torque Control** set to zero becomes non-directional.

On the other hand, the **Torque Control Type** setting corresponding to an overcurrent unit allows to select the type of directional unit in charge of subordinating it. The possible values that this setting can take for the different types of overcurrent units are indicated in the following.

Phase Overcurrent (Instantaneous or Time Elements):

67F (Phase Directional Element).
67P (Positive Sequence Directional Element). This option has been designed for series compensation lines. The polarization of the positive sequence directional element (positive sequence voltage with memory) enables generating correct directional decisions on voltage reversal.

Ground Overcurrent (Instantaneous or Time Elements):

67N (Ground Directional Element).
67Q (Negative Sequence Directional Element).

The 67Q option may be interesting vs. the 67N option when very low V0 voltage levels are anticipated, less than the minimum threshold to polarize the ground directional unit. This condition may arise in very strong zero-sequence source systems (low impedance of zero-sequence local source). On the other hand, the 67Q option may be of interest when there are large mutual couplings (zero sequence) with a parallel line, which could distort the V0 voltage.

Negative Sequence Overcurrent (Instantaneous or Time Elements):

67Q (Negative Sequence Directional Element).

3.1.4 Block Trip and Bypass Time

Both instantaneous and time overcurrent elements can program **Block Trip** inputs, which prevents the operation of the element if this input is activated before the trip is generated. If activated after the trip, it resets. To be able to use these logic input signals, it is necessary to program the status contact inputs defined as block trip.

Another programmable input can change a time overcurrent element into an instantaneous element. This input is called **Bypass Time** and is available for all the time overcurrent elements.

3.1.5 Operation of the Overcurrent Elements

3.1.5.a Instantaneous Elements

Operation of the instantaneous elements is shown in the block diagrams of Figures 3.1.17, 3.1.18 and 3.1.19.

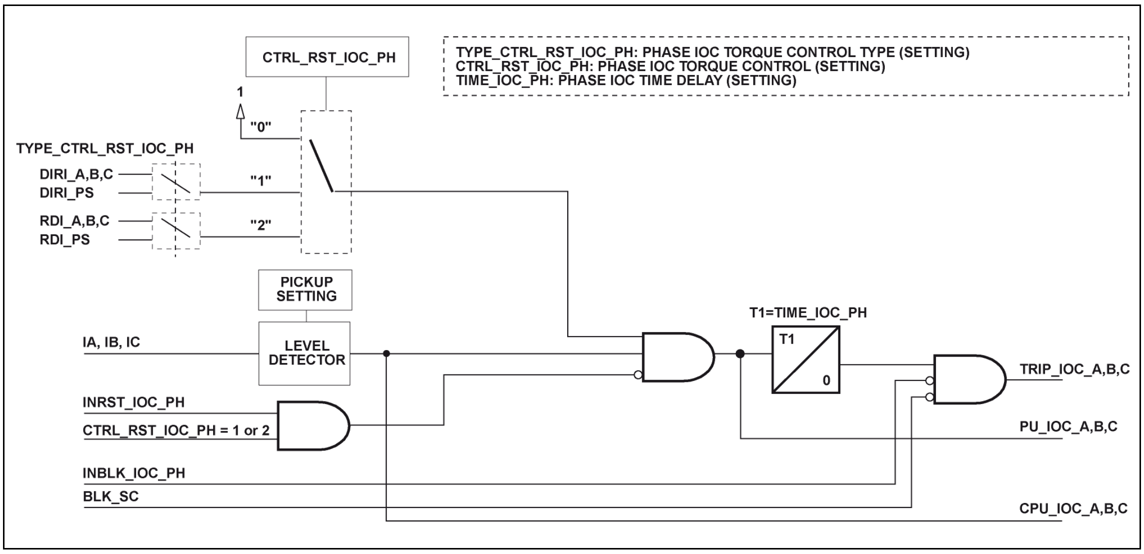


Figure 3.1.17 Block Diagram of a Phase Instantaneous Overcurrent Element.

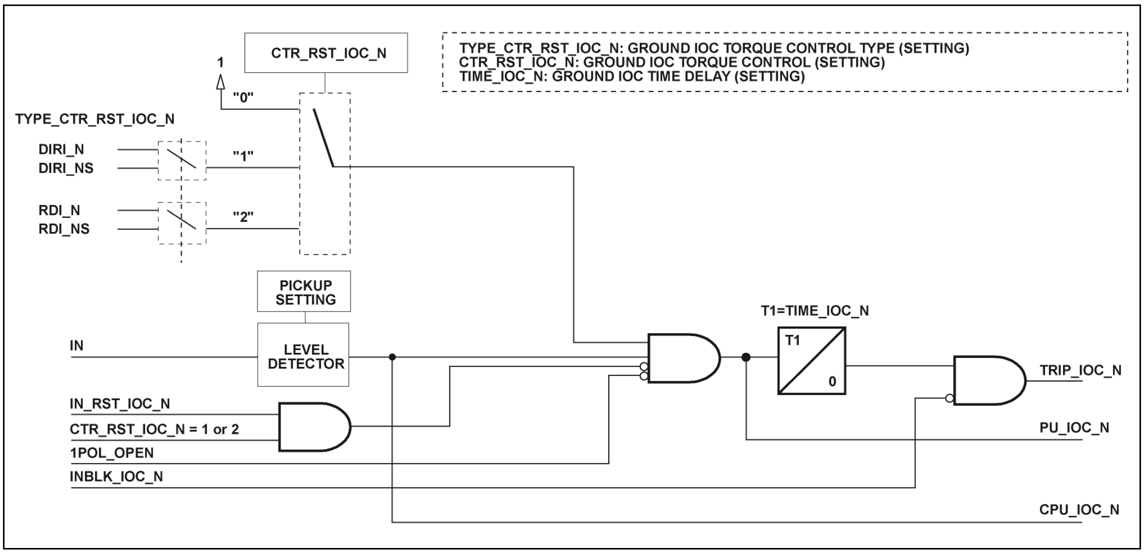


Figure 3.1.18 Block Diagram of a Ground Instantaneous Overcurrent Element.

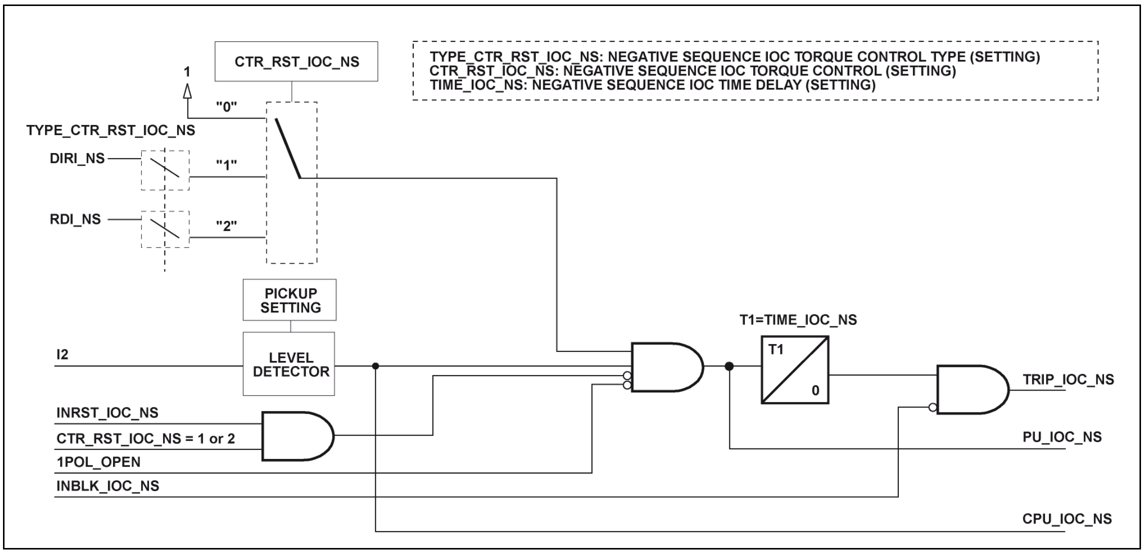


Figure 3.1.19 Block Diagram of a Negative Sequence Instantaneous Overcurrent Element.

Figures 3.1.18 and 3.1.19 show the blocking that the **One Open Pole** (**1POL_OPEN**) signal carries out on the ground and negative sequence overcurrent units, in order to prevent its pickup in case of a new situation originated by the aperture of a pole.

The **Torque Disable** input associated with each instantaneous overcurrent unit (**INRST_IOC**) blocks the pickup of the unit, provided that this includes directionality (torque control = 1 or 2). The **Directional** (**DIRI**) and **Counter Directional** (**RDI**) signals included in the previous diagrams originate from the directional units described in 3.2.

3.1.5.b Time-Delayed Elements

Operation of the time delayed elements is also shown in the block diagrams of Figures 3.1.20, 3.1.21 and 3.1.22.

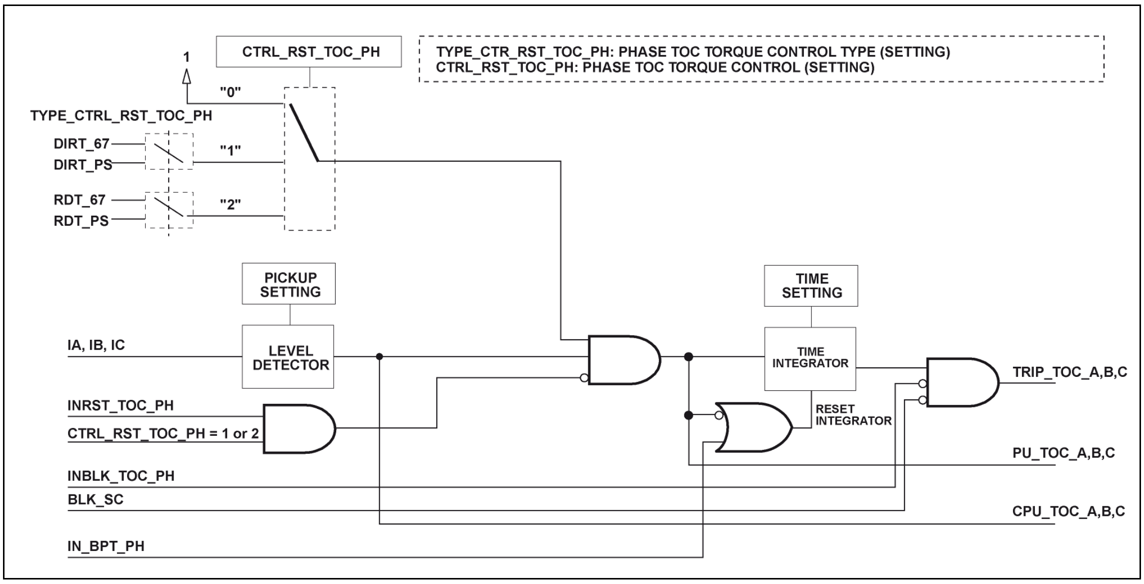


Figure 3.1.20 Block Diagram of a Phase Time Overcurrent Element.

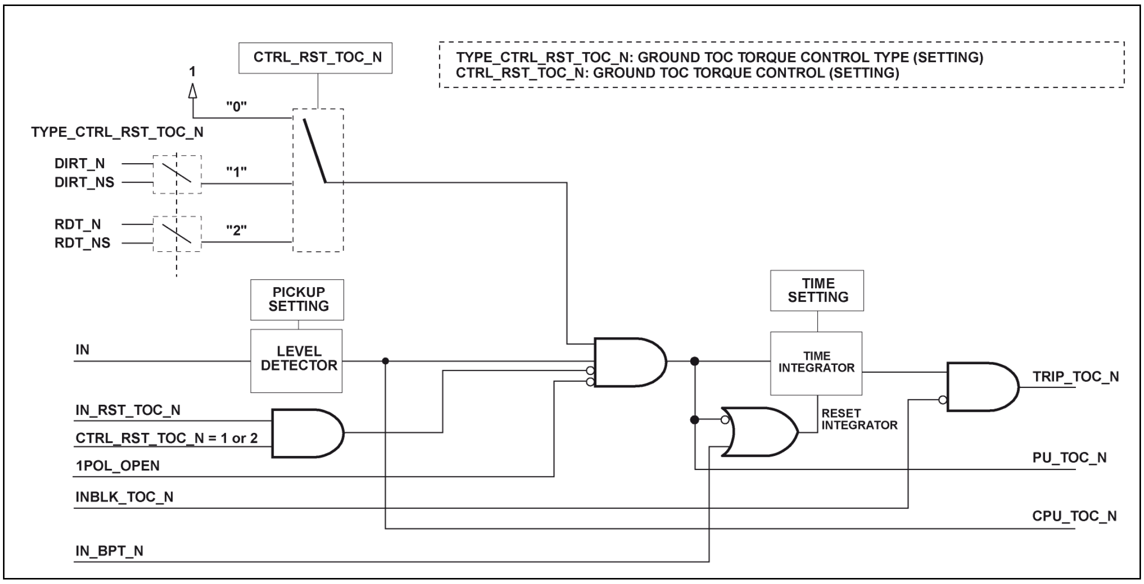


Figure 3.1.21 Block Diagram of a Ground Time Overcurrent Element.

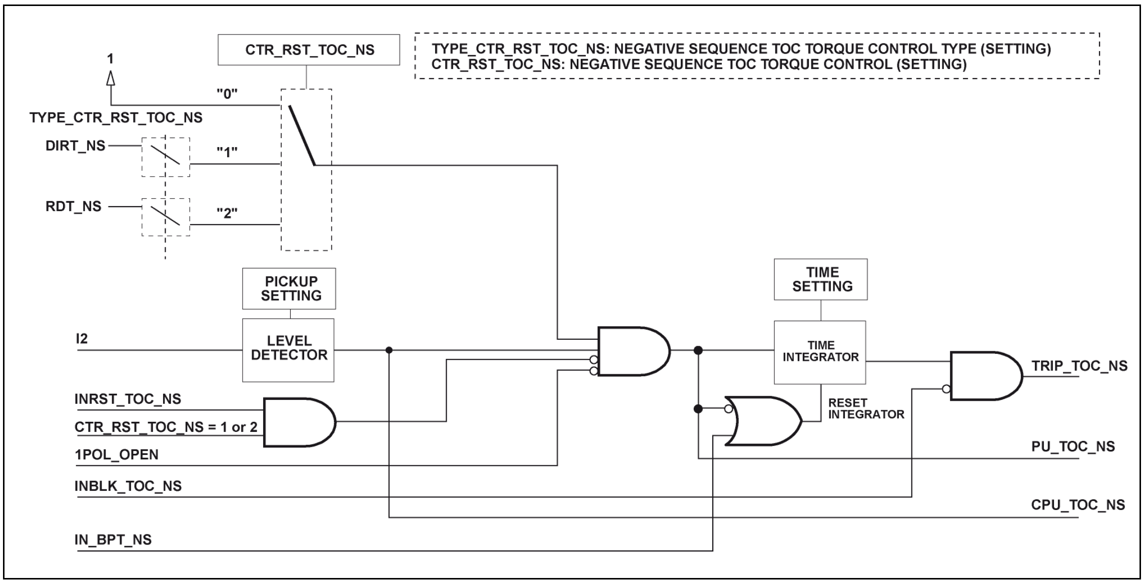


Figure 3.1.22 Block Diagram of a Negative Sequence Time Overcurrent Element.

Figures 3.1.21 and 3.1.22 show the blocking that the **Open Pole** (**1POL_OPEN**) signal carries out on ground and negative sequence overcurrent units, in order to prevent its pickup in case of a new situation arising as a result of the aperture of a pole.

The **Torque Disable** input associated with each time overcurrent unit (**INRST_TOC**) blocks the pickup of the unit provided that this includes directionality (torque control =1 or 2). The **Directional** (**DIRT**) and **Counter Directional** (**RDT**) signals included in the previous diagrams originate from the directional units, described in 3.2.

3.1.6 Overcurrent Elements Settings

Phase Instantaneous Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.01 - 30) In	0.01 A	In
Time Delay	0 - 300 s	0.01 s	0 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Phase directional element (67F) 1: Positive Sequence Dir. Unit (67P)		0: Phase dir. element

Ground Instantaneous Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.01 - 30) In	0.01 A	In
Time Delay	0 - 300 s	0.01 s	0 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Ground Dir. Element (67N) 1: Negative Seq. Dir. Element (67Q)		0: Ground Dir. element

Negative Sequence Instantaneous Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.01 - 30) In	0.01 A	2 In
Time Delay	0 - 300 s	0.01 s	0 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional

Polarization Channel Instantaneous Overcurrent			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.01 - 30) In	0.01 A	0.2 In
Time Delay	0 - 600 s	0.01 s	0 s

Phase Time Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.02 - 25) In	0.01 A	0.4 In
Time Curve	See curve list		Fixed Time
Inverse Time Curve Dial	0.05 - 10	0.01	1
Effective Range for the IEC Curves	0.05 - 1	0.01	1
Effective Range for the IEEE/US Curves	0.1 - 10	0.01	1
Time Delay	0.05 - 300 s	0.01 s	0.05 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Phase directional element (67F) 1: Positive Seq. Dir. Element (67P)		0: Phase Dir. element

Ground Time Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.02 - 25) In	0.01 A	0.4 In
Time Curve	See curve list		Fixed Time
Inverse Time Curve Dial	0.05 - 10	0.01	1
Effective Range for the IEC Curves	0.05 - 1	0.01	1
Effective Range for the IEEE/US Curves	0.1 - 10	0.01	1
Time Delay	0.05 - 300 s	0.01 s	0.05 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Ground Dir. Element (67N) 1: Negative Seq. Dir. Element (67Q)		0: Ground dir. element

Negative Sequence Time Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.1- 5.0) In	0.01 A	0.4 In
Time Curve	See curve list		Fixed Time
Inverse Time Curve Dial	0.05 - 10	0.01	1
Effective Range for the IEC Curves	0.05 - 1	0.01	1
Effective Range for the IEEE/US Curves	0.1 - 10	0.01	1
Time Delay	0.05 - 300 s	0.01 s	0.05 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional

List of Available Curves

IEC CURVES

Inverse Curve	Inverse Curve + Time Limit
Very Inverse Curve	Very Inverse Curve + Time Limit
Extremely Inverse Curve	Extremely Inverse Curve + Time Limit
Long-Term Inverse Curve	Long-Term Inverse Curve + Time Limit
Short-Term Inverse Curve	Short-Term Inverse Curve + Time Limit

IEEE CURVES

Moderately Inverse Curve	Moderately Inverse Curve + Time Limit
Very Inverse Curve	Very Inverse Curve + Time Limit
Extremely Inverse Curve	Extremely Inverse Curve + Time Limit

US CURVES

Moderately Inverse Curve	Moderately Inverse Curve + Time Limit
Inverse Curve	Inverse Curve + Time Limit
Very Inverse Curve	Very Inverse Curve + Time Limit
Extremely Inverse Curve	Extremely Inverse Curve + Time Limit
Short-Term Inverse Curve	Short-Term Inverse Curve + Time Limit
RI Inverse Curve	
User-Defined Curve	
Fixed Time Characteristic	

- **Overcurrent Elements: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**3 - OVERCURRENT**
3 - INFORMATION	...	...

Time Overcurrent Elements

0 - FUSE FAILURE	0 - DIRECTIONAL	**0 - PHASE TOC**
...	**1 - TIME OVERCURRENT**	**1 - NEGSEQ TOC**
3 - OVERCURRENT	2 - INSTANTANEOUS	**2 - GROUND TOC**
...		

0 - PHASE TOC	**0 - UNIT 1**	**0 - PHASE TOC ENABLE**
1 - NEGSEQ TOC	**1 - UNIT 2**	**1 - PHASE TOC PICKUP**
2 - GROUND TOC	**2 - UNIT 3**	**2 - PHASE TOC CURVE**
		3 - PHASE TOC DIAL
		4 - PHASE TOC DELAY
		5 - PH TOC DIRECTION
		6 - PHASE TOC DIR UNT

0 - PHASE TOC	**0 - UNIT 1**	**0 - N.S. TOC ENABLE**
1 - NEGSEQ TOC	**1 - UNIT 2**	**1 - N.S. TOC PICKUP**
2 - GROUND TOC	**2 - UNIT 3**	**2 - N.S. TOC CURVE**
		3 - N.S. TOC DIAL
		4 - N.S. TOC DELAY
		5 - N.S. TOC DIRECTION

0 - PHASE TOC	**0 - UNIT 1**	**0 - GROUND TOC ENABLE**
1 - NEGSEQ TOC	**1 - UNIT 2**	**1 - GROUND TOC PICKUP**
2 - GROUND TOC	**2 - UNIT 3**	**2 - GROUND TOC CURVE**
		3 - GROUND TOC DIAL
		4 - GROUND TOC DELAY
		5 - GND TOC DIRECTION
		6 - GROUN TOC DIR UNT

Instantaneous Phase Overcurrent

0 - FUSE FAILURE	0 - DIRECTIONAL	**0 - PHASE IOC**
…	1 - TIME OVERCURRENT	**1 - NEGSEQ IOC**
3 - OVERCURRENT	**2 - INSTANTANEOUS**	**2 - GROUND IOC**
…		**3 - IPOL CHANNEL IOC (*)**

0 - PHASE IOC	**0 - UNIT 1**	**0 - PHASE IOC ENABLE**
1 - NEGSEQ IOC	**1 - UNIT 2**	**1 - PHASE IOC PICKUP**
2 - GROUND IOC	**2 - UNIT 3**	**2 - PHASE IOC DELAY**
		3 - PHASEIOC DIRECTION
		4 - PHASE IOC DIR UNT

0 - PHASE IOC	**0 - UNIT 1**	**0 - N.S. IOC ENABLE**
1 - NEGSEQ IOC	**1 - UNIT 2**	**1 - N.S. IOC PICKUP**
2 - GROUND IOC	**2 - UNIT 3**	**2 - N.S. IOC DELAY**
		3 - N.S. IOC DIRECTION

0 - PHASE IOC	**0 - UNIT 1**	**0 - GND IOC ENABLE**
1 - NEGSEQ IOC	**1 - UNIT 2**	**1 - GND IOC PICKUP**
2 - GROUND IOC	**2 - UNIT 3**	**2 - GND IOC DELAY**
		3 - GND IOC DIRECTION
		4 - GND IOC DIREC UNIT

0 - PHASE IOC	**0 - IPOL IOC ENABLE**
1 - NEGSEQ IOC	**1 - IPOL IOC PICKUP**
2 - GROUND IOC	**2 - IPOL IOC DELAY**
3 - IPOL CHANNEL IOC (*)	

(*) 6IRV-*-*****1* or higher Models.**

3.1.7 Digital Inputs and Events of the Overcurrent Modules

Table 3.1-1: Digital Inputs and Events of the Overcurrent Modules

Name	Description	Function
INBLK_IOC_PH1	Phase instantaneous element 1 block trip input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
INBLK_IOC_N1	Ground instantaneous element 1 block trip input	
INBLK_IOC_NS1	Neg. sequence instantaneous element 1 block trip input	
INBLK_IOC_PH2	Phase instantaneous element 2 block trip input	
INBLK_IOC_N2	Ground instantaneous element 2 block trip input	
INBLK_IOC_NS2	Negative sequence instantaneous element 2 block trip input	
INBLK_IOC_PH3	Phase instantaneous element 3 block trip input	
INBLK_IOC_N3	Ground instantaneous element 3 block trip input	
INBLK_IOC_NS3	Negative sequence instantaneous element 3 block trip input	
IPOL_BLK_IOC	Ipol instantaneous channel block trip input	
INBLK_TOC_PH1	Phase time element 1 block trip input	
INBLK_TOC_N1	Ground time element 1 block trip input	
INBLK_TOC_NS1	Negative sequence time element 1 block trip input	
INBLK_TOC_PH2	Phase time element 2 block trip input	
INBLK_TOC_N2	Ground time element 2 block trip input	
INBLK_TOC_NS2	Negative sequence time element 2 block trip input	
INBLK_TOC_PH3	Phase time element 3 block trip input	
INBLK_TOC_N3	Ground time element 3 block trip input	
INBLK_TOC_NS3	Negative sequence time element 3 block trip input	
INRST_IOC_PH1	Phase instantaneous element 1 torque annulment input	It resets the element's timing functions and keeps them at 0 as long as it is active. With the element configured in directional mode, if the corresponding monitoring setting and the input are active, trip is blocked for lack of determining the direction.
IN_RST_IOC_N1	Ground instantaneous element 1 torque annulment input	
INRST_IOC_NS1	Negative sequence instantaneous element 1 torque annulment input	
INRST_IOC_PH2	Phase instantaneous element 2 torque annulment input	
IN_RST_IOC_N2	Ground instantaneous element 2 torque annulment input	
INRST_IOC_NS2	Negative sequence instantaneous element 2 torque annulment input	
INRST_IOC_PH3	Phase instantaneous element 3 torque annulment input	
IN_RST_IOC_N3	Ground instantaneous element 3 torque annulment input	
INRST_IOC_NS3	Negative sequence instantaneous element 3 torque annulment input	
INRST_TOC_PH1	Phase time element 1 torque annulment input	
IN_RST_TOC_N1	Ground time element 1 torque annulment input	
INRST_TOC_NS1	Negative sequence time element 1 torque annulment input	

Table 3.1-1: Digital Inputs and Events of the Overcurrent Modules

Name	Description	Function
INRST_TOC_PH2	Phase time element 2 torque annulment input	It resets the element's timing functions and keeps them at 0 as long as it is active. With the element configured in directional mode, if the corresponding monitoring setting and the input are active, trip is blocked for lack of determining the direction.
IN_RST_TOC_N2	Ground time element 2 torque annulment input	
INRST_TOC_NS2	Negative sequence time element 2 torque annulment input	
INRST_TOC_PH3	Phase time element 3 torque annulment input	
IN_RST_TOC_N3	Ground time element 3 torque annulment input	
INRST_TOC_NS3	Negative sequence time element 3 torque annulment input	
IN_BPT_PH1	Phase time element 1 bypass time input	It converts the set timing sequence of a given element to instantaneous.
IN_BPT_N1	Ground time element 1 bypass time input	
IN_BPT_NS1	Negative sequence time element 1 bypass time input	
IN_BPT_PH2	Phase time element 2 bypass time input	
IN_BPT_N2	Ground time element 2 bypass time input	
IN_BPT_NS2	Negative sequence time element 2 bypass time input	
IN_BPT_PH3	Phase time element 3 bypass time input	
IN_BPT_N3	Ground time element 3 bypass time input	
IN_BPT_NS3	Negative sequence time element 3 bypass time input	
ENBL_IOC_PH1	Phase instantaneous element 1 enable input	Activation of this input puts the element into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_IOC_N1	Ground instantaneous element 1 enable input	
ENBL_IOC_NS1	Negative sequence instantaneous element 1 enable input	
ENBL_IOC_PH2	Phase instantaneous element 2 enable input	
ENBL_IOC_N2	Ground instantaneous element 2 enable input	
ENBL_IOC_NS2	Negative sequence instantaneous element 2 enable input	
ENBL_IOC_PH3	Phase instantaneous element 3 enable input	
ENBL_IOC_N3	Ground instantaneous element 3 enable input	
ENBL_IOC_NS3	Negative sequence instantaneous element 3 enable input	
ENBL_IOC_IPOL	Ipol channel instantaneous element enable input	
ENBL_TOC_PH1	Phase time element 1 enable input	
ENBL_TOC_N1	Ground time element 1 enable input	
ENBL_TOC_NS1	Negative sequence time element 1 enable input	
ENBL_TOC_PH2	Phase time element 2 enable input	
ENBL_TOC_N2	Ground time element 2 enable input	
ENBL_TOC_NS2	Negative sequence time element 2 enable input	
ENBL_TOC_PH3	Phase time element 3 enable input	
ENBL_TOC_N3	Ground time element 3 enable input	
ENBL_TOC_NS3	Negative sequence time element 3 enable input	

3.1.8 Digital Outputs and Events of the Overcurrent Modules

Table 3.1-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
PU_IOC_A1	Phase A instantaneous element 1 pickup	AND logic of the pickup of the current elements with the corresponding torque control input.
PU_IOC_B1	Phase B instantaneous element 1 pickup	
PU_IOC_C1	Phase C instantaneous element 1 pickup	
PU_IOC_N1	Ground instantaneous element 1 pickup	
PU_IOC_NS1	Negative sequence inst. element 1 pickup	
PU_IOC_A2	Phase A instantaneous element 2 pickup	
PU_IOC_B2	Phase B instantaneous element 2 pickup	
PU_IOC_C2	Phase C instantaneous element 2 pickup	
PU_IOC_N2	Ground instantaneous element 2 pickup	
PU_IOC_NS2	Negative sequence inst. element 2 pickup	
PU_IOC_A3	Phase A instantaneous element 3 pickup	
PU_IOC_B3	Phase B instantaneous element 3 pickup	
PU_IOC_C3	Phase C instantaneous element 3 pickup	
PU_IOC_N3	Ground instantaneous element 3 pickup	
PU_IOC_NS3	Negative sequence inst. element 3 pickup	
PU_IOC_IPOL	IPol channel instantaneous element pickup	
PU_TOC_A1	Phase A time element 1 pickup	
PU_TOC_B1	Phase B time element 1 pickup	
PU_TOC_C1	Phase C time element 1 pickup	
PU_TOC_N1	Ground time element 1 pickup	
PU_TOC_NS1	Negative sequence time element 1 pickup	
PU_TOC_A2	Phase A time element 2 pickup	
PU_TOC_B2	Phase B time element 2 pickup	
PU_TOC_C2	Phase C time element 2 pickup	
PU_TOC_N2	Ground time element 2 pickup	
PU_TOC_NS2	Negative sequence time element 2 pickup	
PU_TOC_A3	Phase A time element 3 pickup	
PU_TOC_B3	Phase B time element 3 pickup	
PU_TOC_C3	Phase C time element 3 pickup	
PU_TOC_N3	Ground time element 3 pickup	
PU_TOC_NS3	Negative sequence time element 3 pickup	

Table 3.1-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
PU_IOC	Instantaneous elements pickup (does not generate an event)	Pickup of the grouped current elements.
PU_TOC	Time elements pickup (does not generate an event)	
CPU_IOC_A1	Phase A instantaneous element 1 pickup conditions	Pickup of the current elements, unaffected by the torque control.
CPU_IOC_B1	Phase B instantaneous element 1 pickup conditions	
CPU_IOC_C1	Phase C instantaneous element 1 pickup conditions	
CPU_IOC_N1	Ground instantaneous element 1 pickup conditions	
CPU_IOC_NS1	Negative sequence instantaneous element 1 pickup conditions	
CPU_IOC_A2	Phase A instantaneous element 2 pickup conditions	
CPU_IOC_B2	Phase B instantaneous element 2 pickup conditions	
CPU_IOC_C2	Phase C instantaneous element 2 pickup conditions	
CPU_IOC_N2	Ground instantaneous element 2 pickup conditions	
CPU_IOC_NS2	Negative sequence instantaneous element 2 pickup conditions	
CPU_IOC_A3	Phase A instantaneous element 3 pickup conditions	
CPU_IOC_B3	Phase B instantaneous element 3 pickup conditions	
CPU_IOC_C3	Phase C instantaneous element 3 pickup conditions	
CPU_IOC_N3	Ground instantaneous element 3 pickup conditions	
CPU_IOC_NS3	Negative sequence instantaneous element 3 pickup conditions	
CPU_TOC_A1	Phase A time element 1 pickup conditions	
CPU_TOC_B1	Phase B time element 1 pickup conditions	
CPU_TOC_C1	Phase C time element 1 pickup conditions	
CPU_TOC_N1	Ground time element 1 pickup conditions	
CPU_TOC_NS1	Negative sequence time element 1 pickup conditions	
CPU_TOC_A2	Phase A time element 2 pickup conditions	
CPU_TOC_B2	Phase B time element 2 pickup conditions	
CPU_TOC_C2	Phase C time element 2 pickup conditions	
CPU_TOC_N2	Ground time element 2 pickup conditions	
CPU_TOC_NS2	Negative sequence time element 2 pickup conditions	

Table 3.1-2: Digital Outputs and Events of the Overcurrent Modules		
Name	Description	Function
CPU_TOC_A3	Phase A time element 3 pickup conditions	Pickup of the current elements, unaffected by the torque control.
CPU_TOC_B3	Phase B time element 3 pickup conditions	
CPU_TOC_C3	Phase C time element 3 pickup conditions	
CPU_TOC_N3	Ground time element 3 pickup conditions	
CPU_TOC_NS3	Negative sequence time element 3 pickup conditions	
TRIP_IOC_A1	Phase A instantaneous element 1 trip	Trip of the current elements.
TRIP_IOC_B1	Phase B instantaneous element 1 trip	
TRIP_IOC_C1	Phase C instantaneous element 1 trip	
TRIP_IOC_N1	Ground instantaneous element 1 trip	
TRIP_IOC_NS1	Negative sequence instantaneous element 1 trip	
TRIP_IOC_A2	Phase A instantaneous element 2 trip	
TRIP_IOC_B2	Phase B instantaneous element 2 trip	
TRIP_IOC_C2	Phase C instantaneous element 2 trip	
TRIP_IOC_N2	Ground instantaneous element 2 trip	
TRIP_IOC_NS2	Negative sequence instantaneous element 2 trip	
TRIP_IOC_A3	Phase A instantaneous element 3 trip	
TRIP_IOC_B3	Phase B instantaneous element 3 trip	
TRIP_IOC_C3	Phase C instantaneous element 3 trip	
TRIP_IOC_N3	Ground instantaneous element 3 trip	
TRIP_IOC_NS3	Negative sequence instantaneous element 3 trip	
TRIP_TOC_A1	Phase A time element 1 trip	
TRIP_TOC_B1	Phase B time element 1 trip	
TRIP_TOC_C1	Phase C time element 1 trip	
TRIP_TOC_N1	Ground time element 1 trip	
TRIP_TOC_NS1	Negative sequence time element 1 trip	
TRIP_TOC_A2	Phase A time element 2 trip	
TRIP_TOC_B2	Phase B time element 2 trip	
TRIP_TOC_C2	Phase C time element 2 trip	
TRIP_TOC_N2	Ground time element 2 trip	
TRIP_TOC_NS2	Negative sequence time element 2 trip	
TRIP_TOC_A3	Phase A time element 3 trip	
TRIP_TOC_B3	Phase B time element 3 trip	
TRIP_TOC_C3	Phase C time element 3 trip	
TRIP_TOC_N3	Ground time element 3 trip	
TRIP_TOC_NS3	Negative sequence time element 3 trip	
TRIP_IOC	Instantaneous elements trips (does not generate an event)	Trip of the grouped current elements.
TRIP_TOC	Time elements trips (does not generate an event)	

Table 3.1-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
IOC_PH1_ENBLD	Phase instantaneous element 1 enabled	Indication of enabled or disabled status of the current elements.
IOC_N1_ENBLD	Ground instantaneous element 1 enabled	
IOC_NS1_ENBLD	Negative sequence instantaneous element 1 enabled	
IOC_PH2_ENBLD	Phase instantaneous element 2 enabled	
IOC_N2_ENBLD	Ground instantaneous element 2 enabled	
IOC_NS2_ENBLD	Negative sequence instantaneous element 2 enabled	
IOC_PH3_ENBLD	Phase instantaneous element 3 enabled	
IOC_N3_ENBLD	Ground instantaneous element 3 enabled	
IOC_NS3_ENBLD	Negative sequence instantaneous element 3 enabled	
IOC_IPOL_ENBLD	Ipol channel instantaneous element	
TOC_PH1_ENBLD	Phase time element 1 enabled	
TOC_N1_ENBLD	Ground time element 1 enabled	
TOC_NS1_ENBLD	Negative sequence time element 1 enabled	
TOC_PH2_ENBLD	Phase time element 2 enabled	
TOC_N2_ENBLD	Ground time element 2 enabled	
TOC_NS2_ENBLD	Negative sequence time element 2 enabled	
TOC_PH3_ENBLD	Phase time element 3 enabled	
TOC_N3_ENBLD	Ground time element 3 enabled	
TOC_NS3_ENBLD	Negative sequence time element 3 enabled	
INBLK_IOC_PH1	Phase instantaneous element 1 block trip input	The same as for the digital inputs.
INBLK_IOC_N1	Ground instantaneous element 1 block trip input	
INBLK_IOC_NS1	Negative sequence instantaneous element 1 block trip input	
INBLK_IOC_PH2	Phase instantaneous element 2 block trip input	
INBLK_IOC_N2	Ground instantaneous element 2 block trip input	
INBLK_IOC_NS2	Negative sequence instantaneous element 2 block trip input	
INBLK_IOC_PH3	Phase instantaneous element 3 block trip input	
INBLK_IOC_N3	Ground instantaneous element 3 block trip input	
INBLK_IOC_NS3	Negative sequence instantaneous element 3 block trip input	
IPOL_BLK_IOC	Ipol channel instantaneous block trip input	
INBLK_TOC_PH1	Phase time element 1 block trip input	
INBLK_TOC_N1	Ground time element 1 block trip input	
INBLK_TOC_NS1	Negative sequence time element 1 block trip input	
INBLK_TOC_PH2	Phase time element 2 block trip input	
INBLK_TOC_N2	Ground time element 2 block trip input	
INBLK_TOC_NS2	Negative sequence time element 2 block trip input	
INBLK_TOC_PH3	Phase time element 3 block trip input	
INBLK_TOC_N3	Ground time element 3 block trip input	
INBLK_TOC_NS3	Negative sequence time element 3 block trip input	

Table 3.1-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
INRST_IOC_PH1	Phase instantaneous element 1 torque annulment input	The same as for the digital inputs.
IN_RST_IOC_N1	Ground instantaneous element 1 torque annulment input	
INRST_IOC_NS1	Negative sequence instantaneous element 1 torque annulment input	
INRST_IOC_PH2	Phase instantaneous element 2 torque annulment input	
IN_RST_IOC_N2	Ground instantaneous element 2 torque annulment input	
INRST_IOC_NS2	Negative sequence instantaneous element 2 torque annulment input	
INRST_IOC_PH3	Phase instantaneous element 3 torque annulment input	
IN_RST_IOC_N3	Ground instantaneous element 3 torque annulment input	
INRST_IOC_NS3	Negative sequence instantaneous element 3 torque annulment input	
INRST_TOC_PH1	Phase time element 1 torque annulment input	
IN_RST_TOC_N1	Ground time element 1 torque annulment input	
INRST_TOC_NS1	Negative sequence time element 1 torque annulment input	
INRST_TOC_PH2	Phase time element 2 torque annulment input	
IN_RST_TOC_N2	Ground time element 2 torque annulment input	
INRST_TOC_NS2	Negative sequence time element 2 torque annulment input	
INRST_TOC_PH3	Phase time element 3 torque annulment input	
IN_RST_TOC_N3	Ground time element 3 torque annulment input	
INRST_TOC_NS3	Negative sequence time element 3 torque annulment input	
IN_BPT_PH1	Phase time element 1 bypass time input	The same as for the digital inputs.
IN_BPT_N1	Ground time element 1 bypass time input	
IN_BPT_NS1	Negative sequence time element 1 bypass time input	
IN_BPT_PH2	Phase time element 2 bypass time input	
IN_BPT_N2	Ground time element 2 bypass time input	
IN_BPT_NS2	Negative sequence time element 2 bypass time input	
IN_BPT_PH3	Phase time element 3 bypass time input	
IN_BPT_N3	Ground time element 3 bypass time input	
IN_BPT_NS3	Negative sequence time element 3 bypass time input	

Table 3.1-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
ENBL_IOC_PH1	Phase instantaneous element 1 enable input	The same as for the digital inputs.
ENBL_IOC_N1	Ground instantaneous element 1 enable input	
ENBL_IOC_NS1	Negative sequence instantaneous element 1 enable input	
ENBL_IOC_PH2	Phase instantaneous element 2 enable input	
ENBL_IOC_N2	Ground instantaneous element 2 enable input	
ENBL_IOC_NS2	Negative sequence instantaneous element 2 enable input	
ENBL_IOC_PH3	Phase instantaneous element 3 enable input	
ENBL_IOC_N3	Ground instantaneous element 3 enable input	
ENBL_IOC_NS3	Negative sequence instantaneous element 3 enable input	
ENBL_IOC_IPOL	IPol channel instantaneous element enable input	
ENBL_TOC_PH1	Phase time element 1 enable input	
ENBL_TOC_N1	Ground time element 1 enable input	
ENBL_TOC_NS1	Negative sequence time element 1 enable input	
ENBL_TOC_PH2	Phase time element 2 enable input	
ENBL_TOC_N2	Ground time element 2 enable input	
ENBL_TOC_NS2	Negative sequence time element 2 enable input	
ENBL_TOC_PH3	Phase time element 3 enable input	
ENBL_TOC_N3	Ground time element 3 enable input	
ENBL_TOC_NS3	Negative sequence time element 3 enable input	

3.1.9 Overcurrent Elements Test

It is recommended that the overcurrent units be tested one by one, disabling those that are not being tested at any given time. For this test, the directionality of the IED should be annulled to not depend on the voltages (setting **Enable Pickup Blocking** or **Torque Control** to **NO**). Otherwise, they must be injected so the units will be in the trip enable zone.

- **Pickup and Reset**

The desired pickup values for the relevant unit must be set and its activation checked by operating any output configured for this purpose. This can also be verified by checking the pickup flags of the menu **Information** - **Status** - **Measuring Elements** - **Overcurrent**. It can also be checked that the trip flag of this menu is activated if the unit trips.

Table 3.1-3: Pickup and Reset of the Overcurrent Elements

Setting of the unit	Pickup		Reset	
	Maximum	Minimum	Maximum	Minimum
X	1.08 **x** X	1.02 **x** X	1.03 **x** X	0.97 **x** X

In the low ranges, the pickup and reset interval can be extended up to X ± (5% x In) mA.

- **Operating Times**

They are verified with trip outputs C4-C5.

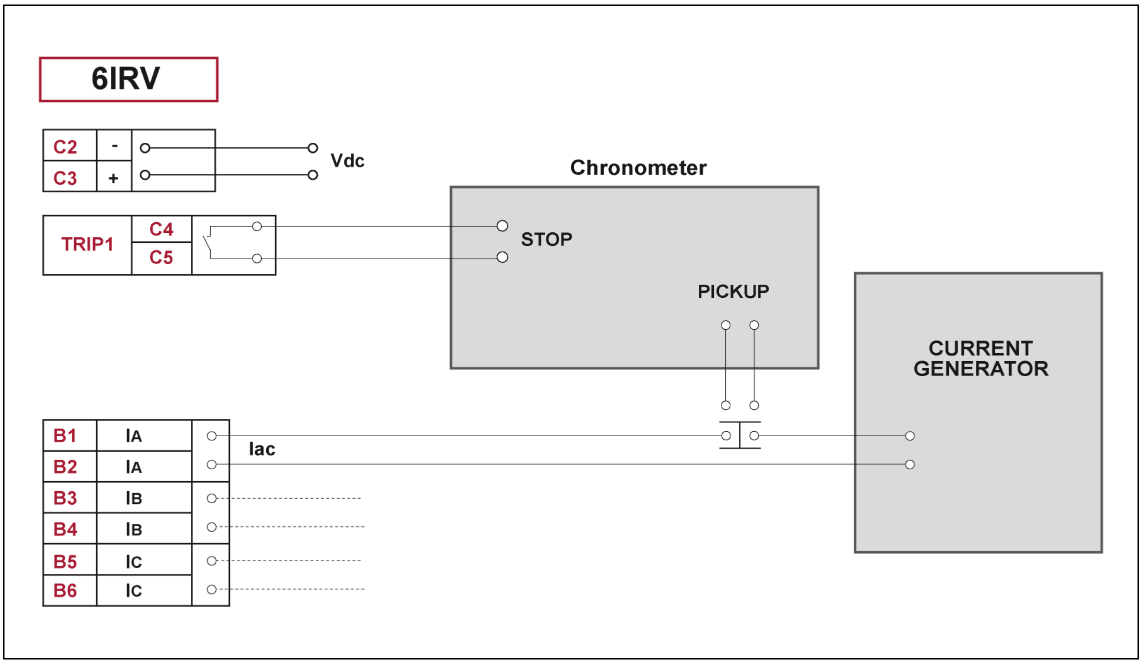


Figure 3.1.23 Operating Time Test Setup.

Fixed Time or Instantaneous

The pickup setting is increased 20%. Operating time should be the selected time setting ±1% or ±20 ms (whichever is greater). A setting of 0 ms will have an operating time between 20 and 25 ms.

Inverse Time

For a given curve, the operating time is determined by the time dial setting and the current applied (number of times of the pickup setting value). The tolerance is determined by applying a margin of error of ±1% in the current measurement. This means an error of ±2% or ±20 ms (whichever is greater) in the measuring times.

Operating times for model **6IRV** can be checked for curves shown in paragraph 3.1.2 according to IEC and IEEE/ANSI standards. RI Inverse Curve characteristic is added to these curves, mainly used in combination with electromechanical relays.

3.2 Directional Elements

3.2.1 Introduction

6IRV relays are provided with the following directional elements for overcurrent element control:

- One directional phase element (67F).
- One directional ground element (67N).
- One directional negative sequence element (67Q).
- One directional positive sequence element (67P).

The mission of the directional element is to determine the direction in which the operating current is flowing in order to control its associated overcurrent element. The direction is determined by comparing its phase with that of a reference value, the phase of which is maintained irrespective of the direction of the flow of the operating current.

Each directional element controls the corresponding overcurrent elements as long as the **Torque Control** setting is other than **Zero**. The control over the overcurrent element is carried out inhibiting the operation of the pickup elements in case the current flows in the reverse direction to that selected. If the directional element inhibits the operation of the overcurrent element, the timing function will not start. If the inhibition occurs once the timing has started, it will reset so that the timing will start again from zero if the inhibition disappears. In any case, a trip requires the timing function to be uninterrupted.

If the **Torque Control** is equal to **Zero**, the directional control is inhibited and allows the pickup of the overcurrent elements for current flows in both directions: direction and reverse direction.

In all cases, the directional element can enable and block trips in both directions (direction and reverse direction) with the **Torque Control** setting (**1** for the direction and **2** for the reverse direction). With **Torque Annulment** input activated, the corresponding directional element is not allowed to pick up.

The **Trip Direction Reversal** input (**IN_INV_TRIP**) changes, if activated, the direction of operation of all the directional elements.

All the directional elements generate direction and reverse direction outputs, instantaneous as well as timed, which exercise directional control over the instantaneous and time overcurrent elements, respectively. The timing of the timed outputs of the directional elements is given by the **Coordination Time** setting.

The **Coordination Time** setting is applicable when teleprotection schemes are used in permissive overreach, created through the **Timing Annulment** input associated with these elements. The following wiring should be carried out for this: pickup output of the time elements to the channel activation input of the teleprotection equipment and channel reception output of the teleprotection equipment to the timer annulment input of the time element.

The **Coordination Time** avoids erroneous trips in case of current reversal produced in double circuits. We consider the case of two parallel lines; the detection of a fault and its subsequent sequential trip in one of these may cause current reversal of one of the terminals of the parallel line, started as a result of this fault. In this case, the directional element will reverse its status and will go on not to allow the trip. If because of the Permissive Overreach the timer is annulled, an instantaneous trip will be produced, since the channel reception signal has a reset time other than zero. To prevent this possibility, the **Coordination Time** may be used, which delays the application of the directional permission until the channel reception signal has disappeared. This delay only affects the time elements, provided that they are configured as directional.

3.2.2 Phase Directional Element

There is one directional element per phase. Phase operate magnitude is phase current and polarization magnitude is phase-to-phase voltage corresponding to the other two phases memorized 2 cycles before pickup.

Figure 3.2-1 shows operation and polarization magnitudes applied to each of three phases.

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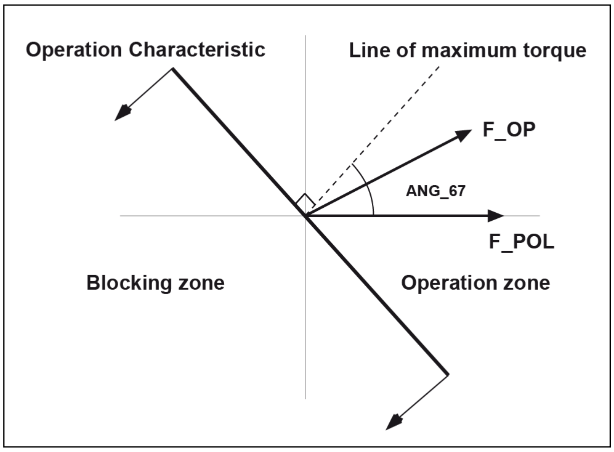


Figure 3.2.1: Block Diagram of a Directional Phase Element.

The phase directional elements check that the current and the voltages of the phases are above certain values. This value is adjustable for the voltage (**Minimum Phase Voltage** setting) and 0.02 In (with In being the rated current of the IED) for the current. If currents and voltages do not exceed their threshold values the above mentioned checking criterion is discontinued, signal **No Phase Polarization** (**LP_DIR_PH**) is activated and the **No Polarization Lockout** setting is checked. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates blocking by lack of polarization, trips in both directions are blocked.

Following table shows the operating and polarization values applied to each of the three phases.

Table 3.2-1: Phase Directional Element			
ABC Phases Sequence			
Phase	**Fop**	**Fpol**	**Criteria**
A	I_A	$U_{BCM} = (V_B - V_C)_M$	$-(90^o - ANG\_67) \le [\arg(Fop) - \arg(Fpol)] \le (90^o + ANG\_67)$
B	I_B	$U_{CAM} = (V_C - V_A)_M$	
C	I_C	$U_{ABM} = (V_A - V_B)_M$	
ACB Phases Sequence			
Phase	**Fop**	**Fpol**	**Criteria**
A	I_A	$U_{CBM} = (V_C - V_B)_M$	$-(90^o - ANG\_67) \le [\arg(Fop) - \arg(Fpol)] \le (90^o + ANG\_67)$
B	I_B	$U_{ACM} = (V_A - V_C)_M$	
C	I_C	$U_{BAM} = (V_B - V_A)_M$	

Drawn on a polar plot, the operation characteristic is a straight line the perpendicular of which (line of maximum torque) is rotated a certain angle counter clockwise, called characteristic angle, with respect to the polarization value. This straight line divides the plane into two semiplanes. This characteristic angle is the complementary to the argument of the positive sequence line impedance (see 3.2.2.a, Example of Application).

The directional element, if configured in direction, enables the overcurrent element when the above criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram). As already mentioned, directional control is phase by phase.

The logic diagram of operation of the phase directional element is shown in Figure 3.2.2

The activation of the **Phase Directional Element Inhibition** (**INH_DIR_PH**) input converts the element to **Non-directional**.

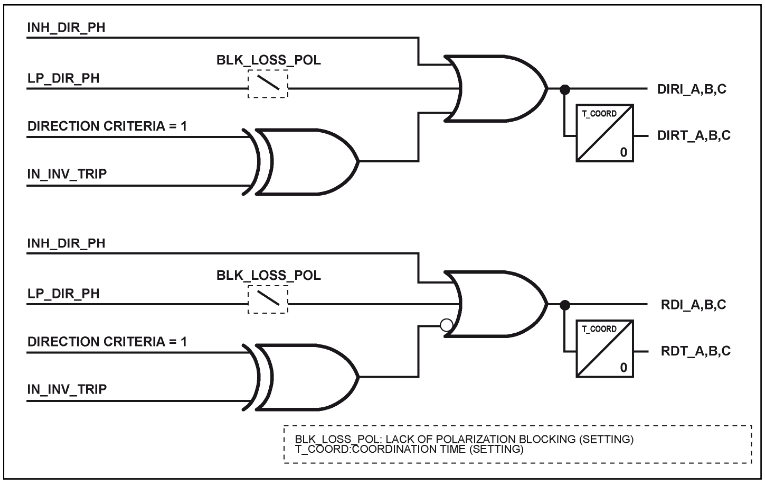


Figure 3.2.2: Block Diagram of a Directional Phase Element.

The **Inversion of the Trip Direction** (**IN_INV_TRIP**) input changes, if activated, the direction of operation of the directional element.

3.2.2.a Example of Application

This section will analyze the setting value of the characteristic angle for the phases with respect to the polarization magnitude that the IED uses to establish the line of maximum torque. This gives rise to the operation and blocking zones of the phase differential elements in **Direction** mode.

The simplest case is a three-phase line open at one of its ends. Suppose a single-phase fault of phase A to ground and without default impedance. If the impedance of the line is **ZI**α, the current $\mathbf{I_A}$ that will flow through the fault will be generated by the presence of voltage $\mathbf{V_A}$ and delayed with respect to it, an angle α.

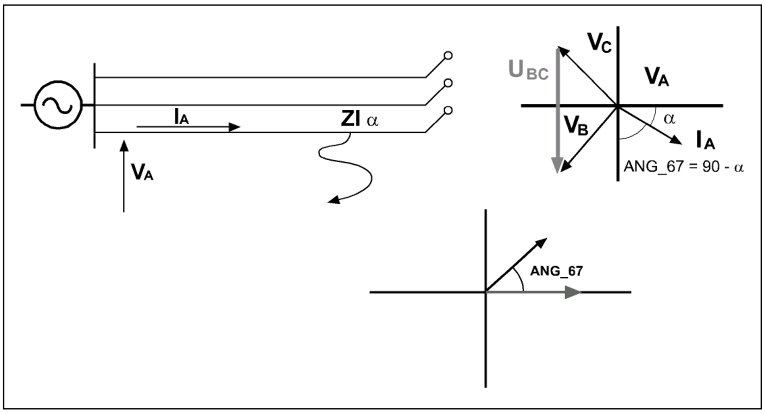


Figure 3.2.3: Graphics for the Example of Application.

6IRV IEDs with directional elements for the phases do not use the simple phase currents as polarization value for each of their corresponding operating values (the currents of each phase). The polarization values used are the phase-to-phase voltages between the other two phases not involved in the possible single-phase fault.

As the graphics show, for a fault in phase A like the one described initially, the polarization value that the IED uses to decide whether or not there is a trip is voltage $U_{BC} = V_B - V_C$, which is delayed in quadrature with respect to the simple voltage of faulted phase V_A.

Given that the characteristic angle (**ANG_67**) that adjusts to the IED is that which is between the operation value and the polarization value (see figure 3.2.1), the value assigned to it must be the angle complementary to the argument of the “impedance of the line”. Everything said so far for phase A can be extrapolated directly for phases B and C.

In conclusion, if the impedance of the line is **ZI**α, the characteristic angle (**ANG_67**) that must be adjusted for the phases is: **ANG_67 = 90 -** α

3.2.3 Directional Ground Element

To operate, the directional ground element uses zero sequence and ground magnitudes. The operating magnitude is the zero sequence current, using two source signals to obtain the polarization magnitude:

- Zero sequence voltage: The zero sequence voltage (V0) is calculated with the phase voltages as follows:

$$\overline{V_0} = \frac{\overline{V_A} + \overline{V_B} + \overline{V_C}}{3}$$

- Circulating current through grounding

In this case, there are two operation characteristics, one corresponding to each of the two modes, which, when drawn on a polar plot, are straight lines, each of which divides the plane into two semiplanes. The location of the operating value determines the output of the directional element and its action on the overcurrent element.

3.2.3.a Polarization by Voltage

In this case, the operating principle of the ground directional element rests on the determination of the phase difference between the zero sequence current and a "compensated" zero sequence voltage based on **the Zero Sequence Voltage Compensation Factor** (K_{COMP_67N}).setting. Figure 3.2.4 diagrams the elements used to explain how polarization by voltage works.

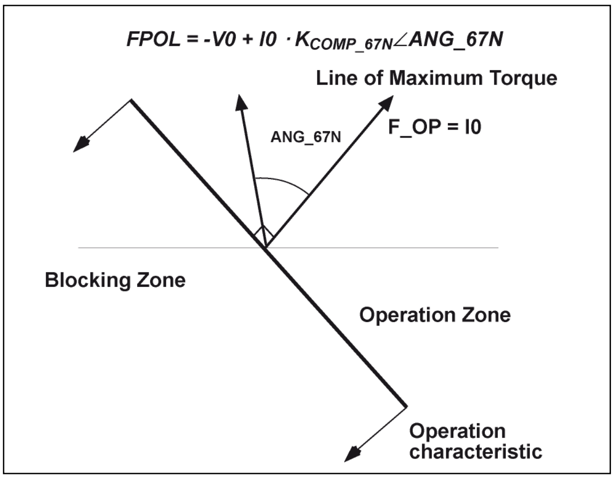


Figure 3.2.4: Vector Diagram of the Directional Ground Element (Polarization by Voltage).

The Directional Ground Element checks that the polarization currents are above a certain value. This value is adjustable for the polarization phasor (**Minimum Zero Sequence Voltage** setting) and **0.02 In** (with **In** being the rated current of the IED) for the operation phasor. If the operation or polarization phasors do not exceed the threshold values, the **No Ground Polarization** (**LP_DIR_N**) signal will be activated and **Blocking due to Lack of Polarization** setting is shown. If this setting indicates that there is NO blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates blocking due to lack of polarization, trips in both directions are blocked.

Depending on the **Neutral Voltage Origin (Transformer / Calculated)** setting, the source of the zero sequence voltage used for polarization varies. It can be calculated as the vector sum of the three phase voltages (**Calculated**) or directly measured through a dedicated analog input VN (**Transformer**).

The following table shows the operation and polarization phasors which intervene in the ground directional element, as well as the operation criteria applied.

Table 3.2-2:Directional Ground Element (polarization by voltage)		
Fop	**Fpol**	**Criteria**
I0	$-V0+I0\cdot K_{COMP\_67N}\angle ANG\_67N$	$-\left(90^{o}+ANG\_67N\right)\leq\left[\arg\left(Fop\right)-\arg\left(Fpol\right)\right]\leq\left(90^{o}-ANG\_67N\right)$

The directional element, if configured in direction, enables the overcurrent element when the previous criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

Figures 3.2.5 and 3.2.6 show the zero sequence network for a ground fault (single phase or two phase) in a forward and reverse direction, respectively.

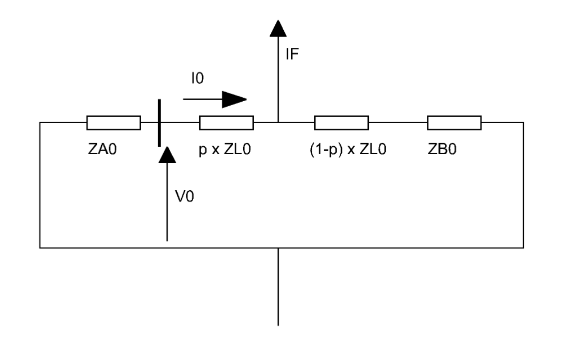


Figure 3.2.5: Zero Sequence Network for Forward Fault.

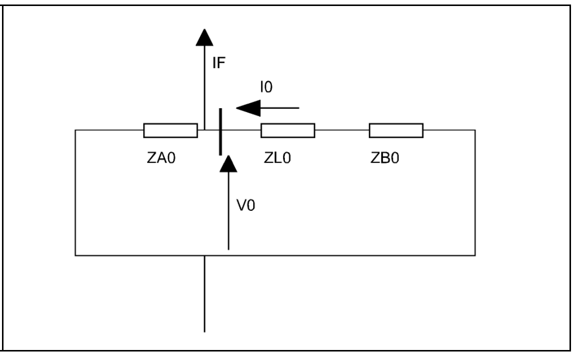


Figure 3.2.6: Zero Sequence Network for Reverse Fault.

If the fault is in forward direction, it can be deduced that $V0 = ZA0\cdot(-I0)$, where $ZA0$ is the zero sequence impedance of the local source. It is seen, consequently, that the angle between $-V0$ and $I0$ will be that corresponding to this impedance. For this reason, this should be the characteristic angle of the ground directional element (**ANG_67N** setting).

If the fault is in the reverse direction, the following expression will be obtained: $V0 = (ZL0 + ZB0)\cdot I0$, where $ZL0$ and $ZB0$ are the zero sequence impedance of the line and the remote source, respectively. Consequently, the angle between $-V0$ and $I0$ will be supplementary of the angle of $ZL0 + ZB0$ impedance (which will be similar to the $ZA0$ angle).

Through the relative phase difference between $-V0$ and $I0$, the directionality of the fault can be deduced. However, the K_{COMP_67N} factor is used for the following two reasons:

Increase the polarization phasor magnitude, in order that this exceeds the **Minimum Zero Sequence Voltage**:

When the zero sequence impedance of the local source is small, in case of forward fault, the $V0$ voltage which measures the relay may present values under the **Minimum Zero Sequence Voltage** setting [it was previously deduced that $V0 = ZA0 \cdot (-I0)$]. In order to have sufficient voltage to polarize the ground directional element, a new voltage with the same phase is added to the $-V0$ phasor, which will correspond to the voltage drop in an impedance with **ANG_67N** angle (it is assumed that this adjustment will be equal to the $ZA0$ angle) and with a magnitude equal to K_{COMP_67N}. The effect of the new polarization phasor is that of expanding the zero sequence impedance magnitude of the local source with a value equal to K_{COMP_67N}.

The K_{COMP_67N} value should be restricted in order that the ground directional element does not take any erroneous directional decisions in case of faults in the reverse direction. When the fault is in the reverse direction $V0 = (ZL0 + ZB0) \cdot I0$, as was deduced previously. If we assume that the $ZL0 + ZB0$ angle is similar to the **ANG_67N** setting (assumption equal to $ZA0$ angle), $-V0$ and $I0 \cdot K_{COMP\_67N}$ will be in anti-phase, for which the sum of $I0 \cdot K_{COMP\_67N}$ reduces the polarization phasor value, with it being possible to even reverse its direction. The latter would occur if $K_{COMP\_67N} > (ZL0 + ZB0)$; in this case, the directional element would consider that the fault is in forward direction. For this reason, the K_{COMP_67N} value is restricted by the $ZL0 + ZB0$ value.

Compensate the inversion that the V0 voltage may undergo in lines with series compensation:

In case of faults in a forward direction, in a line with series compensation, $V0$ will be reversed (approximately 180º considering that the angle of source impedance is close to 90º), provided that the zero sequence impedance existing between the voltage transformer and the local source is capacitive. In this case, the directional element will act erroneously since it will consider that the fault is in the reverse direction. In order to rotate the reversed $-V0$ voltage 180º, such that the directional element can see the fault in a forward direction, a K_{COMP_67N} factor should be applied whose value exceeds the capacitive reactance value introduced. Notwithstanding, and in order to avoid erroneous directional decisions in case of reverse directional faults, as was indicated previously, K_{COMP_67N} should be less than $ZL0 + ZB0$ (impedance existing between the voltage transformer and the remote source).

- **Polarization by Current**

Determining the phase displacement between the residual current and the current circulating through the grounding is simple because the phase displacements between the two magnitudes can only be 0º and 180º or, what is the same, the characteristic angle must always be 0º.

When it is configured in direction, the operation zone is the zone in which the fault or operating current **In** is rotated 180º with respect to the current flowing through the grounding. As in the figure, **F_POL** is equal to the current flowing through the grounding (**IPT**) rotated 180º. Therefore, **F_POL** and **In** must be in phase to be in the operation zone. When it is configured in reverse direction, it enables the overcurrent element in the opposite semiplane. Figure 3.2.7 shows the vector diagram associated with the ground directional element when the polarization by current is used.

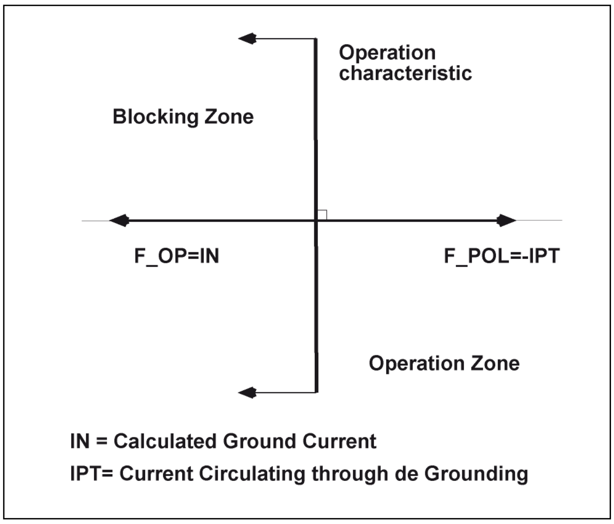


Figure 3.2.7: Vector Diagram of the Directional Ground Element (Polarization by Current).

The following table shows the operation and polarization phasors which intervenes in the ground directional element, as well as the operation criteria applied.

Table 3.2-3: Directional Ground Element (Polarization by Current)		
Fop	**Fpol**	**Criteria**
I0	-IPT	$-90º \leq \arg(F\_OP) - \arg(F\_POL) \leq 90º$

The directional element, if configured in direction, enables the overcurrent element when the previous criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

- **Polarization by Voltage and Current**

If both polarizations coexist, the criterion is the following: If the directional ground element is not inhibited, it checks that the current is above a minimum value. If it does not exceed this, the **No Ground Polarization** (**LP_DIR_N**) signal is activated and the **Blocking due to Lack of Polarization Voltage** setting is shown. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates trip blocking, trips in both directions are blocked.

If it is above the minimum value, it checks that the polarization current is above a given value. If it is, it determines whether or not there is trip direction. If the **Direction Inversion Input** (**IN_INV_TRIP**) is active, the calculated direction is changed.

If the polarization by current solves the directionality (enables trip), the element does not check polarization by voltage. If the polarization by current does not solve the directionality, the element verifies that the polarization voltage is above a given adjustable value (**Ground Minimum Voltage**). If this is not the case, the **No Ground Polarization** (**LP_DIR_N**) signal is activated and the **Blocking due to Lack of Polarization Voltage** setting is shown. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates trip blocking, trips in both directions are blocked.

If the voltage level is correct, it is determined if there is trip direction according to the criteria indicated. If the **Direction Inversion Input** (**IN_INV_TRIP**) input is active, the direction of the calculated direction is changed.

The activation of the **Directional Ground Element Inhibit** (**INH_DIR_N**) input converts the element to non-directional.

The logic diagram of operation of the ground directional element is shown in Figure 3.2.8.

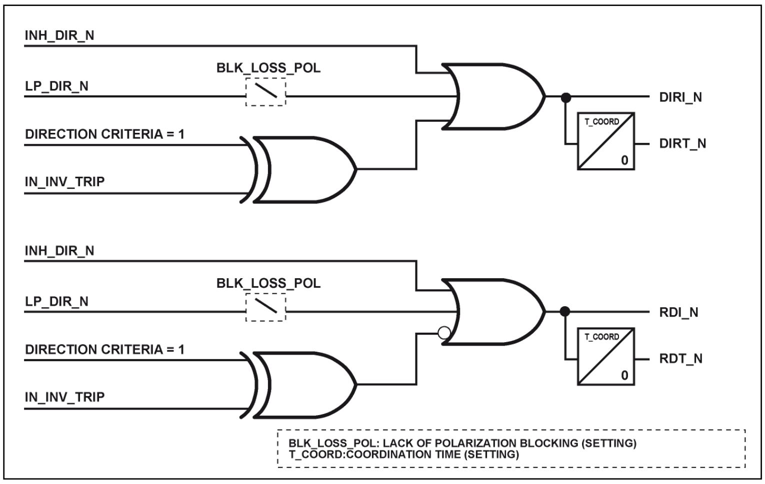


Figure 3.2.8: Block Diagram of a Directional Ground Element.

3.2.4 Directional Negative Sequence Element

The operating principle of a directional negative sequence element rests on the determination of the relative phase difference between the negative sequence current and a "compensated" negative sequence voltage based on the **Negative Sequence Voltage Compensation Factor** (K_{COMP_67Q}) setting. Figure 3.2.9 presents the vector diagram associated with the directional negative sequence element.

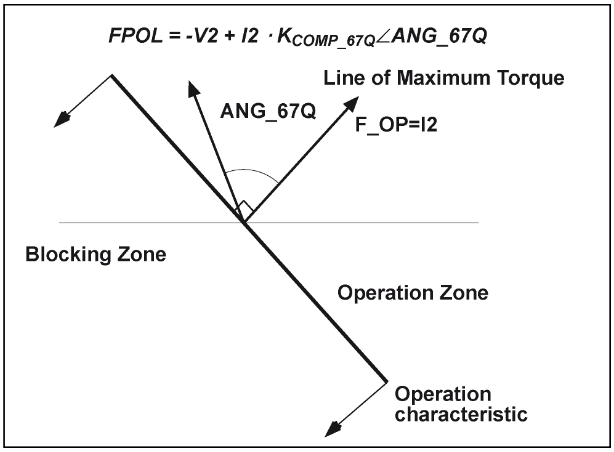


Figure 3.2.9: Vector Diagram of the Directional Negative Sequence Element.

The directional negative sequence element verifies that the operation and polarization phasors exceed certain determined values. This value is adjustable for the polarization phasor (**Minimum Negative Sequence Voltage** setting) and **0.02 In** (with **In** being the rated current of the IED) for the operation phasor. If the operation or polarization phasors do not exceed the threshold values, the **No Negative Sequence Polarization** (**LP_DIR_NS**) signal will be activated and the **Blocking due to Lack of Polarization** setting is shown. If this setting indicates that there is **NO** blocking, the same procedure as in case of directional inhibition is carried out; but if it indicates blocking due to lack of polarization, the trips in both directions are blocked.

The following table shows the operation and polarization phasors which intervene in the directional negative sequence element, as well as the operation criteria applied.

Table 3.2-4:Directional Negative Sequence Element		
Fop	**Fpol**	**Criteria**
I2	$-V2+I2\cdot K_{COMP\_67Q}\angle ANG\_67Q$	$-(90^{o}+ANG\_67Q)\leq[\arg(Fop)-\arg(Fpol)]\leq(90^{o}-ANG\_67Q)$

The directional element, if configured in direction, enables the overcurrent element when the above criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

All that stated for the **Zero Sequence Voltage Compensation Factor** is applicable to the **Sequence Voltage Compensation Factor**, if the negative sequence network is considered instead of the zero sequence network.

Figures 3.2.10 and 3.2.11 show the negative sequence network for a forward and reverse unbalanced fault (single phase or two phase), respectively.

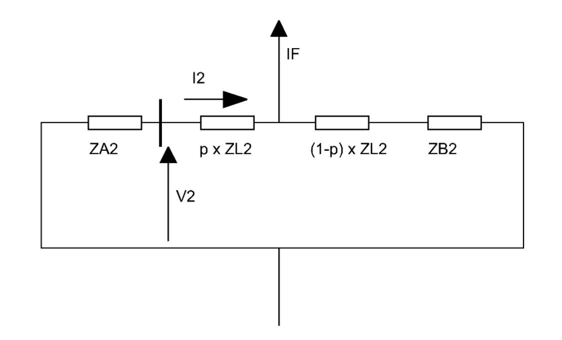


Figure 3.2.10: Negative Sequence Network for Forward Fault.

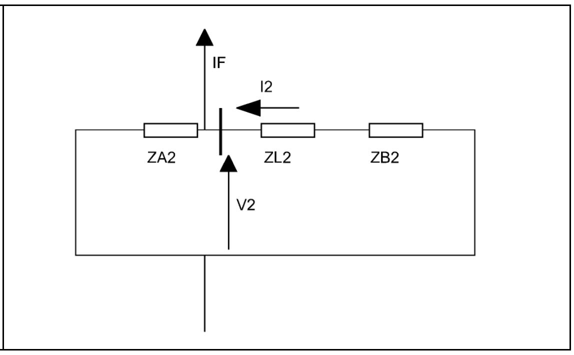


Figure 3.2.11: Negative Sequence Network for Reverse Fault.

If a forward fault, it can be deduced that $-V2 = ZA2 \cdot (-I2)$, where $ZA2$ is the negative sequence impedance of the local source. Consequently, it can be seen that the angle between $-V2$ and $I2$ will be that corresponding to this impedance. For this reason, this should be the characteristic angle of the directional negative sequence element (**ANG_67Q** setting).

The objective of the K_{COMP_67Q} factor is similar to that indicated for the K_{COMP_67N} factor in the ground directional element:

- Increase the polarization phasor magnitude, in order that this exceeds the Minimum negative sequence voltage setting.
- Compensate the inversion that the V2 voltage may undergo in lines with series compensation:

The logic diagram of operation of the directional negative sequence element is shown in Figure 3.2.12.

If the **Inversion of Directionality** (**IN_INV_TRIP D**) input is active, the direction of calculated direction is changed.

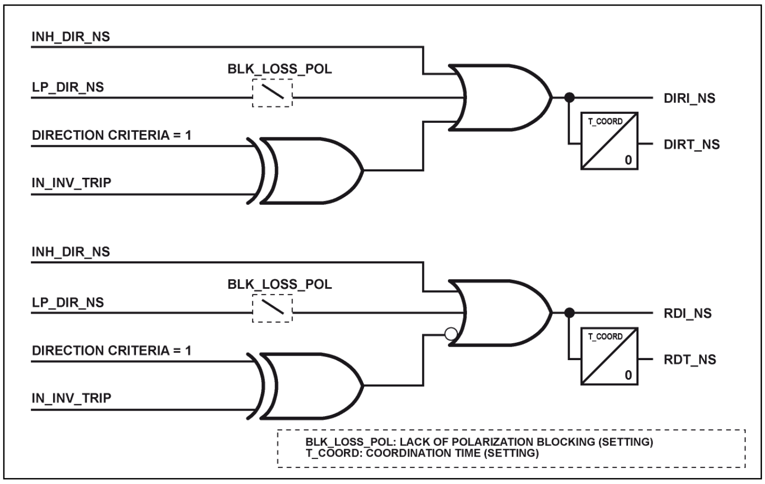


Figure 3.2.12: Block Diagram of a Directional Negative Sequence Element.

The activation of the **Ground Directional Element Inhibit** (**INH_DIR_NS**) input converts the element into non-directional.

3.2.5 Positive Sequence Directional Unit

The operation is based on determining the phase difference between positive sequence current and positive sequence voltage memorized two cycles in advance of fault detector activation (see Chapter 3.14). Figure 3.2.13 shows the phasor diagram associated to the positive sequence directional element.

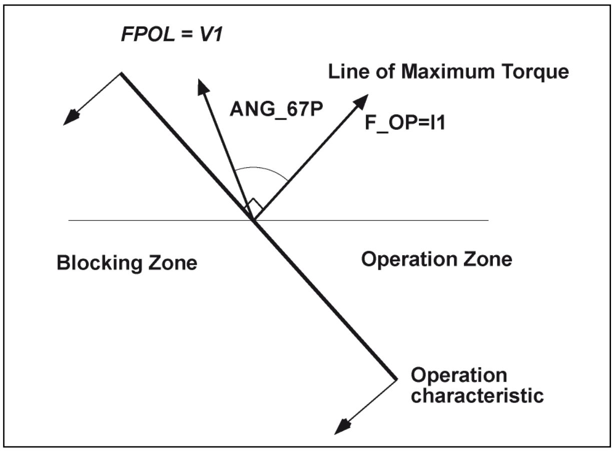


Figure 3.2.13: Vector Diagram of the Positive Sequence Directional Element.

The Positive Sequence Directional Element checks that operation and polarization phasors exceed given values. This value is adjustable for the polarization phasor (**Minimum Zero Sequence Voltage** setting) and **0.02 In** (with **In** being the rated current of the IED) for the operation phasor. If the operation or polarization phasors do not exceed the threshold values the **Lack of Polarization of Positive Sequence** (**LP_DIR_PS**) signal will be activated and **Blocking due to Lack of Polarization** setting is shown. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates blocking due to lack of polarization, trips in both directions are blocked.

The following table shows the operation and polarization phasors which intervene in the Positive Sequence Directional Element, as well as the operation criteria applied.

Table 3.2-5: Positive Sequence Directional Element		
Fop	**Fpol**	**Criteria**
I1	V1	$-\left(90^{o}+ANG\_67P\right)\leq\left[\arg\left(Fop\right)-\arg\left(Fpol\right)\right]\leq\left(90^{o}-ANG\_67P\right)$

The directional element, if configured in direction, enables the overcurrent element when the previous criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

The Positive Sequence Directional Element can supervise the operation of phase overcurrent elements, if their **Torque Control Type** setting is set to **67P**. Thanks to the type of polarization used (**Positive Sequence Voltage with Memory**), the positive sequence directional element operates correctly on voltage reversals produced in series compensated lines.

The logic diagram of operation of the directional positive sequence element is shown in Figure 3.2.14.

If the **Direction Inversion Input** (**IN_INV_TRIP**) is active, the calculated direction is changed.

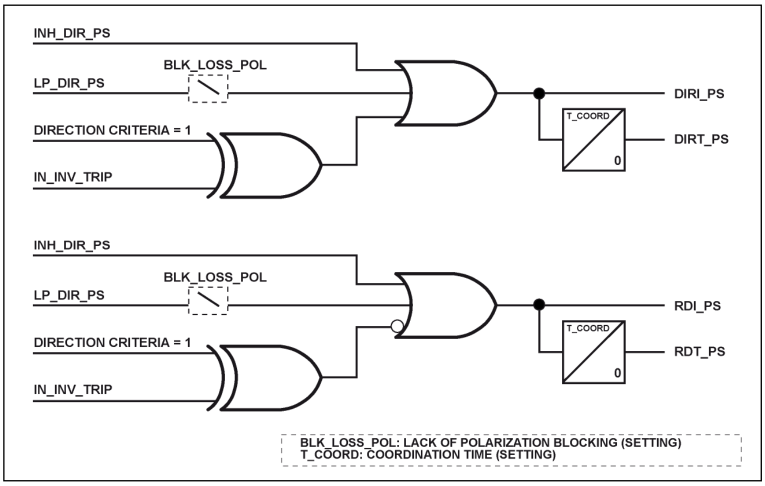


Figure 3.2.14:Block Diagram of a Positive Sequence Directional Element.

The activation of the **Inhibit of the Positive Sequence Directional** (**INH_DIR_NS**) input converts the element to non-directional.

3.2.6 Directional Elements Settings

Directional Elements			
Setting	**Range**	**Step**	**By default**
Phase Characteristic Angle	0º - 90º	1º	45º
Zero Sequence Characteristic Angle	0º - 90º	1º	45º
Negative Sequence Characteristic Angle	0º - 90º	1º	45º
Positive Sequence Characteristic Angle	0º - 90º	1º	45º
Lack of Polarization Blocking	YES / NO		NO
Minimum Phase Voltage	0.05 - 10 V	0.01 V	0.2 V
Minimum Zero Sequence Voltage	0.05 - 10 V	0.01 V	0.2 V
Minimum Negative Sequence Voltage	0.05 - 10 V	0.01 V	0.2 V
Minimum Positive Sequence Voltage	0.05 - 10 V	0,01 V	0,2 V
Coordination Time	0 - 30 ms	1 ms	0 ms
Zero Sequence Voltage Compensation Factor	0.00 - 50	0.01	0
Negative Sequence Voltage Compensation Factor	0.00 - 50	0.01	0

- **Directional Elements: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**3 - OVERCURRENT**
3 - INFORMATION		...

0 - FUSE FAILURE	**0 - DIRECTIONAL**	**0 - PHASE CHARAC ANGLE**
...	1 - TIME OVERCURRENT	**1 - GND. CHARACT. ANGLE**
3 - OVERCURRENT	2 - INSTANTANEOUS	**2 - NEGSEQ CHARACT ANG**
...		**3 - POSSEQ CHARACT ANG**
		4 - LACK POLARIZ BLOCK
		5 - COORD. TIME
		6 - MIN. PHASE VOLTAGE
		7 - MIN. GND VOLTAGE
		8 - MIN. NEG SEQ VOLTAGE
		9 - MIN POSSEQ VOLTAGE
		10 - RESID.VOLT. COMP.
		11 - NEGSEQ VOLT.COMP.

3.2.7 Digital Inputs and Events of the Directional Modules

Table 3.2-6:Digital Inputs and Events of the Directional Modules

Name	Description	Function
INH_DIR_PH	Directional phase element inhibit	The activation of these inputs converts the directional elements into non-directional.
INH_DIR_N	Directional ground element inhibit	
INH_DIR_NS	Directional negative sequence element inhibit	
INH_DIR_PS	Directional positive sequence element inhibit	
INV_TRIP	Inversion of the trip direction	When the input is quiescent, the operation zones are those indicated in this section. If it is activated, the operation zone of all the directional elements is inverted.

3.2.8 Digital Outputs and Events of the Directional Modules

Table 3.2-7: Digital Outputs and Events of the Directional Modules		
Name	**Description**	**Function**
RDI_A	Phase A instantaneous reverse direction	Indication that the current flows in the direction opposite to that of the trip. The signals of time overcurrent elements are activated when the "Coordination Time" is up.
RDI_B	Phase B instantaneous reverse direction	
RDI_C	Phase C instantaneous reverse direction	
RDI_N	Ground instantaneous reverse direction	
RDI_NS	Negative sequence instantaneous reverse direction	
RDI_PS	Positive sequence instantaneous reverse direction	
RDT_A	Phase A time reverse direction	
RDT_B	Phase B time reverse direction	
RDT_C	Phase C time reverse direction	
RDT_N	Ground time reverse direction	
RDT_NS	Negative sequence time reverse direction	
RDT_PS	Positive sequence time reverse direction	
DIRI_A	Phase A instantaneous direction	Indication that the current flows in the direction of the trip. The signals of time overcurrent elements are activated when the "Coordination Time" is up.
DIRI_B	Phase B instantaneous direction	
DIRI_C	Phase C instantaneous direction	
DIRI_N	Ground instantaneous direction	
DIRI_NS	Negative sequence inst. direction	
DIRI_PS	Positive sequence inst. direction	
DIRT_A	Phase A time direction	Indication that the current flows in the direction of the trip. The signals of time overcurrent elements are activated when the "coordination time" is up.
DIRT_B	Phase B time direction	
DIRT_C	Phase C time direction	
DIRT_N	Ground time direction	
DIRT_NS	Negative sequence time direction	
LP_DIR_PH_A	Loss of polarization for phase A	Indication for loss of polarization from the corresponding directional unit.
LP_DIR_PH_B	Loss of polarization for phase B	
LP_DIR_PH_C	Loss of polarization for phase C	
LP_DIR_N	Loss of polarization for ground	
LP_DIR_NS	Loss of polarization for negative sequence	
LP_DIR_PS	Loss of polarization for positive sequence	
INH_DIR_PH	Directional phase element inhibit	The same as for the digital inputs.
INH_DIR_N	Directional ground element inhibit	
INH_DIR_NS	Directional negative sequence element inhibit	
INH_DIR_PS	Directional positive sequence element inhibit	
INV_TRIP	Inversion of the trip direction	The same as for the digital inputs.

3.2.9 Directional Elements Test

The enable **Pickup Blocking** or the **Torque Control** must be set to **Direction** and the inversion of directionality input must not be operational before running the test.

The test can be performed phase by phase: Ia with Vb, Ib with Vc, Ic with Va. Tables 3.2-8, 3.2-9, 3.2-10, 3.2-11 and 3.2-12 present the angles between which the IED must enable direction. Whether or not the IED is seeing direction can be checked with the menu **Information** - **Status** - **Measuring Elements** - **Overcurrent** - **Directional Element** or in the ***ZIVercomPlus***® to **Status** – **Elements** - **Overcurrent** - **Directional** and the states of the flags of the phase being tested must be verified.

Table 3.2-8:Phase Directionality	
V APPLIED	I APPLIED
Vb = 64V⌊0º	Ia = 1A⌊(α phase char. -90º to α phase char. +90º) ± 2º
Vc = 64V⌊0º	Ib = 1A⌊(α phase char. -90º to α phase char. + 90º) ± 2º
Va = 64V⌊0º	Ic = 1A⌊(α phase char. -90º to α phase char. + 90º) ± 2º

Table 3.2-9: Directional Ground by Vpol	
V APPLIED	I APPLIED
Va = 64V⌊180º	In = 1A⌊ (-(90º+ α ground char.) to 90º - α ground char.) ± 2º

Table 3.2-10:Directional Ground by Ipol	
I APPLIED	I APPLIED
Ip = 1A⌊180º	In = 1A⌊(-90º to 90º)

Table 3.2-11: Negative Sequence Directionality	
V APPLIED	I APPLIED
Va = 64V⌊180º	In = 1A⌊ (-(90º+ α negative char.) to 90º - α negative char.) ± 2º

Table 3.2-12:Positive Sequence Directionality	
V APPLIED	I APPLIED
Va = 64V⌊0º	Ia = 1A⌊ (-(90º+ α positive char.) to 90º - α positive char.) ± 2º

3.3 Voltage Elements

3.3.1 Undervoltage Elements

6IRV IEDs have three phase undervoltage elements (27F1, 27F2 and 27F3). They operate when the RMS values of the voltages measured (phase-ground voltages) reach a given value. This value is set simultaneously for the three voltages in each unit.

The undervoltage elements have an associated logic which can be controlled with a setting in which you select between the following two possible types of operation (see figure 3.3.2):

- **AND**: the (27F) element trips when the three associated undervoltage elements (V1, V2 and V3) comply with the trip condition.
- **OR**: the (27F) element trips when one or more of the three associated undervoltage elements (V1, V2 or V3) comply with the trip condition.

Pickup occurs for a given undervoltage element when the value measured is equal to or less than one times the set value, and resets at a selectable percentage (greater) above the setting.

The undervoltage element pickup enables the timing function. This is done by applying increments on a meter that picks up the element when it times out. The time setting included allows selecting a **Fixed Time** timing sequence.

When the RMS exceeds the set pickup, a rapid reset of the integrator occurs. The activation of the output requires the pickup to continue operating throughout the integration. Any reset leads the integrator to its initial conditions so that a new operation initiates the time count from zero.

An analog input can be assigned to the logic signal that blocks the trip signaling of the undervoltage phase elements, thus disabling the output if this signal is activated.

The undervoltage elements will be blocked whenever the **Any Pole Open** (**OR_P_OP**) or **Blocking Due to Fuse Failure** (**BLK_FF**) signals, originating from the Open Pole Logic and Fuse Failure Detector, respectively, are activated.

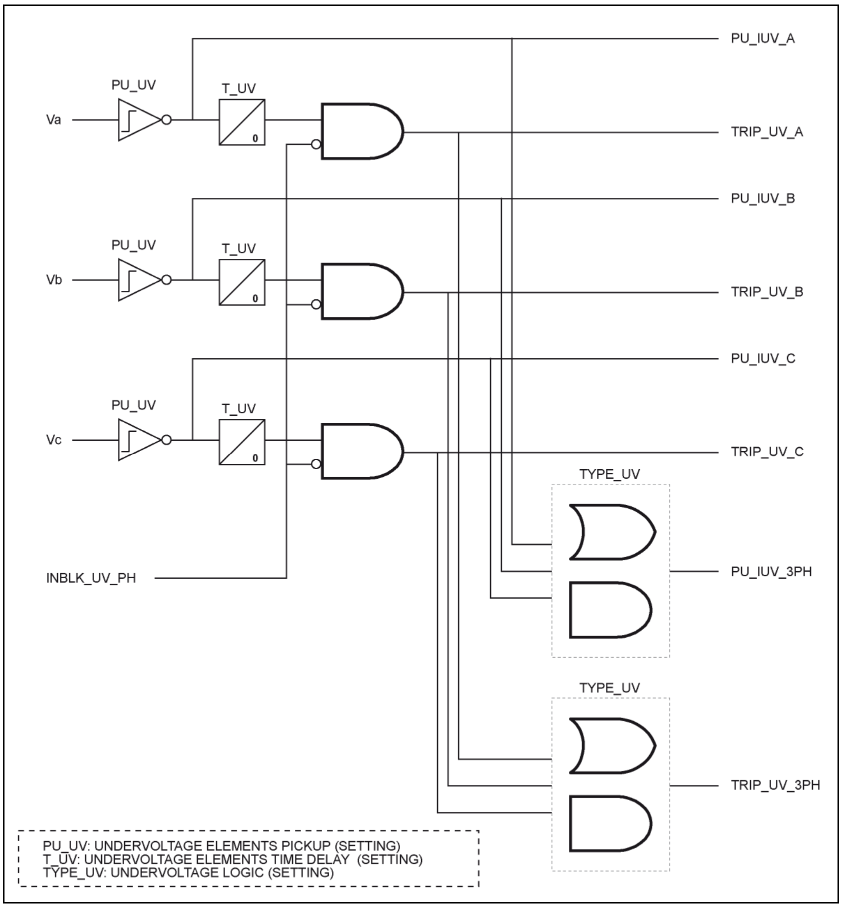


Figure 3.3.1: Block Diagram of Undervoltage Elements.

3.3.2 Overvoltage Elements

6IRV IEDs have the following overvoltage elements:

- Three phase overvoltage elements (59F1, 59F2 and 59F3).
- Two ground overvoltage elements (59N1 and 59N2).

3.3.2.a Phase Overvoltage Elements

They operate when the RMS values of the voltages measured (phase-ground voltages) reach a given value. This value is set simultaneously for the three voltages in each unit.

The overvoltage elements have an associated logic which can be controlled with a setting in which you select between the following two possible types of operation (see figure 3.3.2):

- **AND**: the (59F) element trips when the three associated undervoltage elements (V1, V2 and V3) comply with the trip condition.
- **OR**: the (59F) element trips when one or more of the three associated undervoltage elements (V1, V2 or V3) comply with the trip condition.

Pickup occurs for a given overvoltage element when the value measured is greater than one times the set value, and resets at a selectable percentage (less) of the setting.

The overvoltage element pickup enables the timing function. This is done by applying increments on a meter that picks up the element when it times out. The time setting included allows selecting a fixed time timing sequence.

When the RMS falls below the pickup setting, a rapid reset of the integrator occurs. The activation of the output requires the pickup to continue operating throughout the integration. Any reset leads the integrator to its initial conditions so that a new operation initiates the time count from zero.

You can assign an analog input to the logic signal that blocks the trip signaling of the overvoltage phase elements, thus disabling the output if this signal is activated.

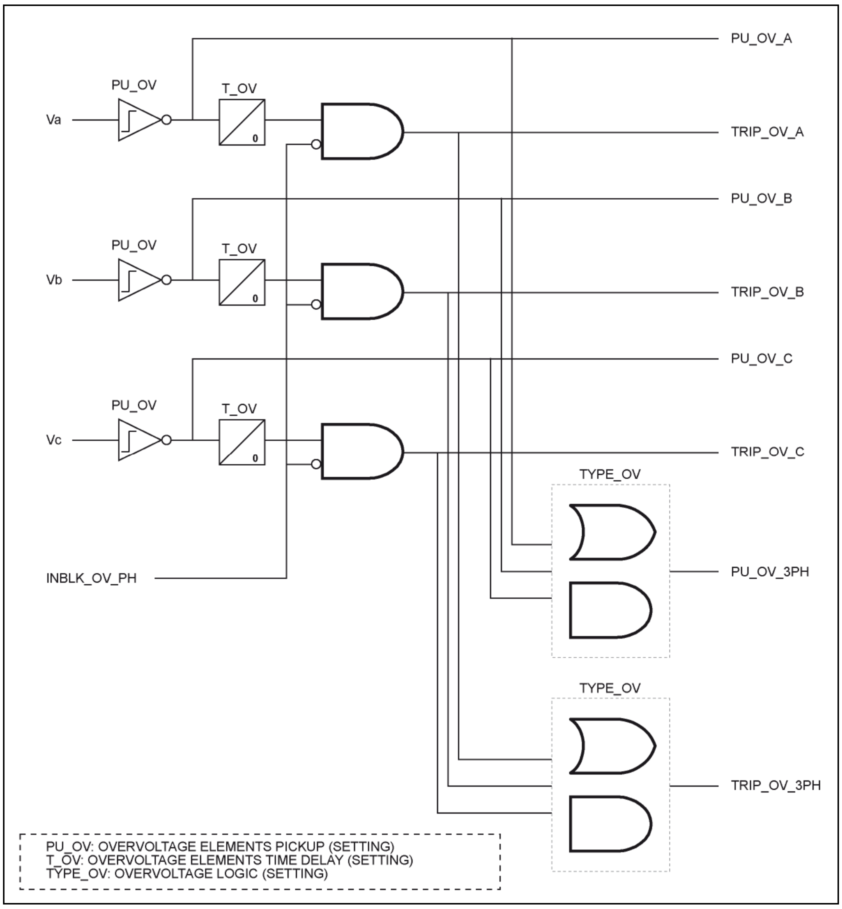


Figure 3.3.2: Block Diagram of Overvoltage Elements.

3.3.2.b Ground Overvoltage Elements

Ground overvoltage elements are made up of an instantaneous overvoltage element with an additional independent adjustable timer.

The ground voltage is calculated using data from the three phase voltages. The RMS value of this ground voltage, which is the operating magnitude of the level detector, is calculated with the phase voltages as follows:

$$\overline{V_N} = \overline{V_A} + \overline{V_B} + \overline{V_C}$$

The adjustable output of this detector is the pickup signal of elements 59N1 and 59N2. It initializes an adjustable timer, whose output, combined with the blocking signal of the unit, in the AND gate is taken as the element's output. See figure 3.3.3.

The ground overvoltage elements will be blocked whenever the **Any Pole Open** (**OR_P_OP**) or **Blocking Due to Fuse Failure** (**BLK_FF**) signals, originating from the **Open Pole Logic** and from the **Fuse Failure Detector**, respectively, are activated.

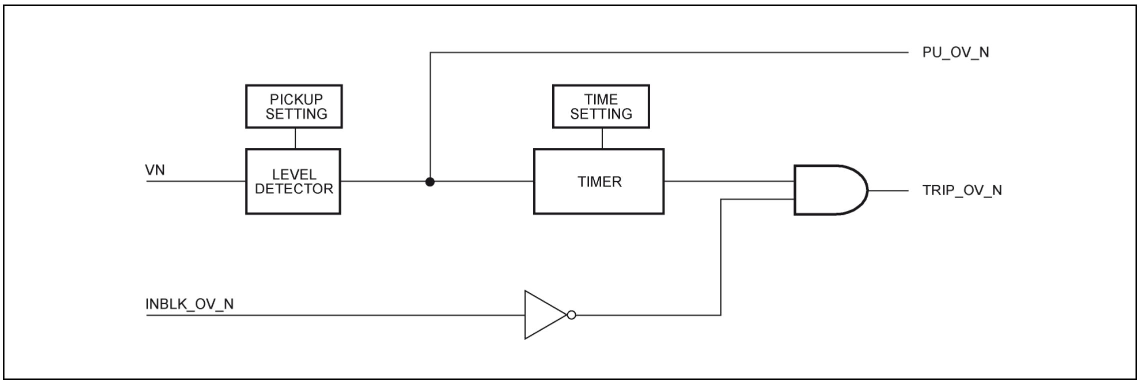


Figure 3.3.3: Block Diagram of a Ground Overvoltage Element.

Each element picks up when the RMS value of the zero sequence voltage exceeds 1 times the set pickup value and resets with a selectable value percentage (lower) of the setting.

Elements 59N1 and 59N2 can program **Block Trip** inputs, which prevents the operation of the element if this input is activated before the trip is generated. If activated after the trip, it resets. To be able to use these logic input signals, it is necessary to program the status contact inputs defined as **Block Trip**.

3.3.3 Voltage Elements Settings

Voltage Dropout			
Setting	**Range**	**Step**	**By default**
Phase overvoltage elements dropout	50 - 99% of setting	1%	95%
Ground overvoltage elements dropout	50 - 99% of setting	1%	95%
Phase undervoltage elements dropout	101 - 150% of setting	1%	105%

Phase Overvoltage (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	20 - 300 V	0.01 V	70 V
Time delay	0 - 300 s	0.01 s	0 s
Tripping logic	OR / AND		OR

Phase Undervoltage (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	10 - 300 V	0.01 V	40 V
Time delay	0 - 300 s	0.01 s	0 s
Tripping logic	OR / AND		OR

Ground Overvoltage (Elements 1 and 2)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	2 - 150 V	0.01 V	10 V
Time delay	0 - 300 s	0.01 s	0 s

- **Voltage Elements: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**4 - VOLTAGE**
3 - INFORMATION	…	…

0 - FUSE FAILURE	**0 - VOLTAGE RESET**
…	**1 - PHASE OVERVOLTAGE**
4 - VOLTAGE	**2 - GROUND OVERVOLTAGE**
…	**3 - PHASE UNDERVOLTAGE**

Voltage Reset

0 - VOLTAGE RESET	**0 - PH. UV RESET**
1 - PHASE OVERVOLTAGE	**1 - PH OV RESET**
2 - GROUND OVERVOLTAGE	**2 - GND OV RESET**
3 - PHASE UNDERVOLTAGE	

Phase Overvoltage

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH. OV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - PH. OV PICKUP**
2 - GROUND OVERVOLTAGE	**2 - UNIT 3**	**2 - PH. OV DELAY**
3 - PHASE UNDERVOLTAGE		**3 - OUTPUT LOGIC PH OV**

Ground Overvoltage

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - GND OV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - GND OV PICKUP**
2 - GROUND OVERVOLTAGE		**2 - GND OV DELAY**
3 - PHASE UNDERVOLTAGE		

Phase Undervoltage

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH. UV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - PH. UV PICKUP**
2 - GROUND OVERVOLTAGE	**2 - UNIT 3**	**2 - PH. UV DELAY**
3 - PHASE UNDERVOLTAGE		**3 - OUTPUT LOGIC PH UV**

3.3.4 Digital Inputs and Events of the Voltage Modules

Table 3.3-1: Digital Inputs and Events of the Voltage Modules		
Name	**Description**	**Function**
INBLK_UV1_PH	Phase undervoltage element 1 block input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
INBLK_UV2_PH	Phase undervoltage element 2 block input	
INBLK_UV3_PH	Phase undervoltage element 3 block input	
INBLK_OV_PH1	Phase overvoltage element 1 block input	
INBLK_OV_PH2	Phase overvoltage element 2 block input	
INBLK_OV_PH3	Phase overvoltage element 3 block input	
INBLK_OV_N1	Ground overvoltage element 1 block input	
INBLK_OV_N2	Ground overvoltage element 2 block input	
ENBL_UV_PH1	Phase undervoltage element 1 enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_UV_PH2	Phase undervoltage element 2 enable input	
ENBL_UV_PH3	Phase undervoltage element 3 enable input	
ENBL_OV_PH1	Phase overvoltage element 1 enable input	
ENBL_OV_PH2	Phase overvoltage element 2 enable input	
ENBL_OV_PH3	Phase overvoltage element 3 enable input	
ENBL_OV_N1	Ground overvoltage element 1 enable input	
ENBL_OV_N2	Ground overvoltage element 2 enable input	

3.3.5 Digital Outputs and Events of the Voltage Modules

Table 3.3-2: Digital Outputs and Events of the Voltage Modules		
Name	**Description**	**Function**
PU_IUV1_A	Phase A undervoltage element 1 pickup	Pickup of the undervoltage and overvoltage elements and start of the time count. Three-phase pickups are those that are generated after the chosen AND or OR algorithm.
PU_IUV2_A	Phase A undervoltage element 2 pickup	
PU_IUV3_A	Phase A undervoltage element 3 pickup	
PU_IUV1_B	Phase B undervoltage element 1 pickup	
PU_IUV2_B	Phase B undervoltage element 2 pickup	
PU_IUV3_B	Phase B undervoltage element 3 pickup	
PU_IUV1_C	Phase C undervoltage element 1 pickup	
PU_IUV2_C	Phase C undervoltage element 2 pickup	
PU_IUV3_C	Phase C undervoltage element 3 pickup	
PU_IUV1_3PH	Three-phase undervoltage element 1 pickup	
PU_IUV2_3PH	Three-phase undervoltage element 2 pickup	
PU_IUV3_3PH	Three-phase undervoltage element 3 pickup	
PU_OV1_A	Phase A overvoltage element 1 pickup	
PU_OV2_A	Phase A overvoltage element 2 pickup	
PU_OV3_A	Phase A overvoltage element 3 pickup	
PU_OV1_B	Phase B overvoltage element 1 pickup	
PU_OV2_B	Phase B overvoltage element 2 pickup	
PU_OV3_B	Phase B overvoltage element 3 pickup	
PU_OV1_C	Phase C overvoltage element 1 pickup	
PU_OV2_C	Phase C overvoltage element 2 pickup	
PU_OV3_C	Phase C overvoltage element 3 pickup	
PU_OV1_N	Ground overvoltage element 1 pickup	
PU_OV2_N	Ground overvoltage element 2 pickup	

Table 3.3-2: Digital Outputs and Events of the Voltage Modules		
Name	**Description**	**Function**
PU_OV1_3PH	Three-phase overvoltage element 1 pickup	Pickup of the undervoltage and overvoltage elements and start of the time count. Three-phase pickups are those that are generated after the chosen AND or OR algorithm.
PU_OV2_3PH	Three-phase overvoltage element 2 pickup	
PU_OV3_3PH	Three-phase overvoltage element 3 pickup	
TRIP_UV1_A	Phase A undervoltage element 1 trip	Trip of the undervoltage and overvoltage elements.
TRIP_UV2_A	Phase A undervoltage element 2 trip	
TRIP_UV3_A	Phase A undervoltage element 3 trip	
TRIP_UV1_B	Phase B undervoltage element 1 trip	
TRIP_UV2_B	Phase B undervoltage element 2 trip	
TRIP_UV3_B	Phase B undervoltage element 3 trip	
TRIP_UV1_C	Phase C undervoltage element 1 trip	
TRIP_UV2_C	Phase C undervoltage element 2 trip	
TRIP_UV3_C	Phase C undervoltage element 3 trip	
TRIP_UV1_3PH	Three-phase undervoltage element 1 trip	
TRIP_UV2_3PH	Three-phase undervoltage element 2 trip	
TRIP_UV3_3PH	Three-phase undervoltage element 3 trip	
TRIP_OV1_A	Phase A overvoltage element 1 trip	
TRIP_OV2_A	Phase A overvoltage element 2 trip	
TRIP_OV3_A	Phase A overvoltage element 3 trip	
TRIP_OV1_B	Phase B overvoltage element 1 trip	
TRIP_OV2_B	Phase B overvoltage element 2 trip	
TRIP_OV3_B	Phase B overvoltage element 3 trip	
TRIP_OV1_C	Phase C overvoltage element 1 trip	
TRIP_OV2_C	Phase C overvoltage element 2 trip	
TRIP_OV3_C	Phase C overvoltage element 3 trip	
TRIP_OV1_N	Ground overvoltage element 1 trip	
TRIP_OV2_N	Ground overvoltage element 2 trip	
TRIP_OV1_3PH	Three-phase overvoltage element 1 trip	
TRIP_OV2_3PH	Three-phase overvoltage element 2 trip	
TRIP_OV3_3PH	Three-phase overvoltage element 3 trip	
UV_PH1_ENBLD	Phase undervoltage element 1 enabled	Indication of enabled or disabled status of the voltage elements.
UV_PH2_ENBLD	Phase undervoltage element 2 enabled	
UV_PH3_ENBLD	Phase undervoltage element 3 enabled	
OV_PH1_ENBLD	Phase overvoltage element 1 enabled	
OV_PH2_ENBLD	Phase overvoltage element 2 enabled	
OV_PH3_ENBLD	Phase overvoltage element 3 enabled	
OV_N1_ENBLD	Ground overvoltage element 1 enabled	
OV_N2_ENBLD	Ground overvoltage element 2 enabled	
INBLK_UV1_PH	Phase undervoltage element 1 block input	The same as for the Digital Inputs.
INBLK_UV2_PH	Phase undervoltage element 2 block input	
INBLK_UV3_PH	Phase undervoltage element 3 block input	

Table 3.3-2: Digital Outputs and Events of the Voltage Modules		
Name	**Description**	**Function**
INBLK_OV_PH1	Phase overvoltage element 1 block input	The same as for the Digital Inputs.
INBLK_OV_PH2	Phase overvoltage element 2 block input	
INBLK_OV_PH3	Phase overvoltage element 3 block input	
INBLK_OV_N1	Ground overvoltage element 1 block input	
INBLK_OV_N2	Ground overvoltage element 2 block input	
ENBL_UV_PH1	Phase undervoltage element 1 enable input	The same as for the Digital Inputs.
ENBL_UV_PH2	Phase undervoltage element 2 enable input	
ENBL_UV_PH3	Phase undervoltage element 3 enable input	
ENBL_OV_PH1	Phase overvoltage element 1 enable input	
ENBL_OV_PH2	Phase overvoltage element 2 enable input	
ENBL_OV_PH3	Phase overvoltage element 3 enable input	
ENBL_OV_N1	Ground overvoltage element 1 enable input	
ENBL_OV_N2	Ground overvoltage element 2 enable input	

3.3.6 Voltage Elements Test

3.3.6.a Overvoltage Elements Test

Before testing the overvoltage unit, all the voltage units that are not being tested must be disabled.

- **Pickup and Reset**

The desired pickup values for the relevant unit are set and their activation is checked by operating any output configured for this purpose. This can also be verified by checking the pickup flags of the menu **Information** - **Status** - **Units**. This verification can also be made by checking that the trip flag of this menu is activated if the unit trips.

Table 3.3-3:Pickup and Reset of the Overvoltage Elements				
Setting of the unit	Pickup		Reset	
X	Maximum	Minimum	Maximum	Minimum
	1.03 x X	0.97 x X	(RST setting + 0.03) x X	(RST setting - 0.03) x X

Where the value “RST setting” corresponds to the setting in per unit of the **Unit Reset** for the overvoltage units.

- **Operating Times**

Outputs C4-C5 are used to verify them [See figure 3.3.4].

Fixed Time or Instantaneous

The pickup setting is increased 20%. Operating time should be the selected time setting ±1% or ±20 ms (whichever is greater). A setting of 0 ms will have an operating time between 20 and 25 ms.

3.3.6.b Undervoltage Elements Test

Before testing the undervoltage unit, all the voltage units that are not being tested must be disabled.

- **Pickup and Reset**

The desired pickup values for the relevant unit are set and their activation is checked by operating any output configured for this purpose. This can also be verified by checking the pickup flags of the menu **Information** - **Status** - **Units**. This verification can also be made by checking that the trip flag of this menu is activated if the unit trips.

Table 3.3-4:Pickup and Reset of the Undervoltage Elements				
Setting of the unit	Pickup		Reset	
X	Maximum	Minimum	Maximum	Minimum
	1.03 x X	0.97 x X	(RST setting + 0.03) x X	(RST setting - 0.03) x X

Where the value “RST setting” is the setting in per unit of the **Unit Reset** for the undervoltage units.

- **Operating Times**

Outputs C4-C5 are used to verify them [See figure 3.3.4].

Fixed Time or Instantaneous

The pickup setting is decreased 20%. Operating time should be the selected time setting ±1% or ±20 ms (whichever is greater). A setting of 0 ms will have an operating time between 20 and 25 ms.

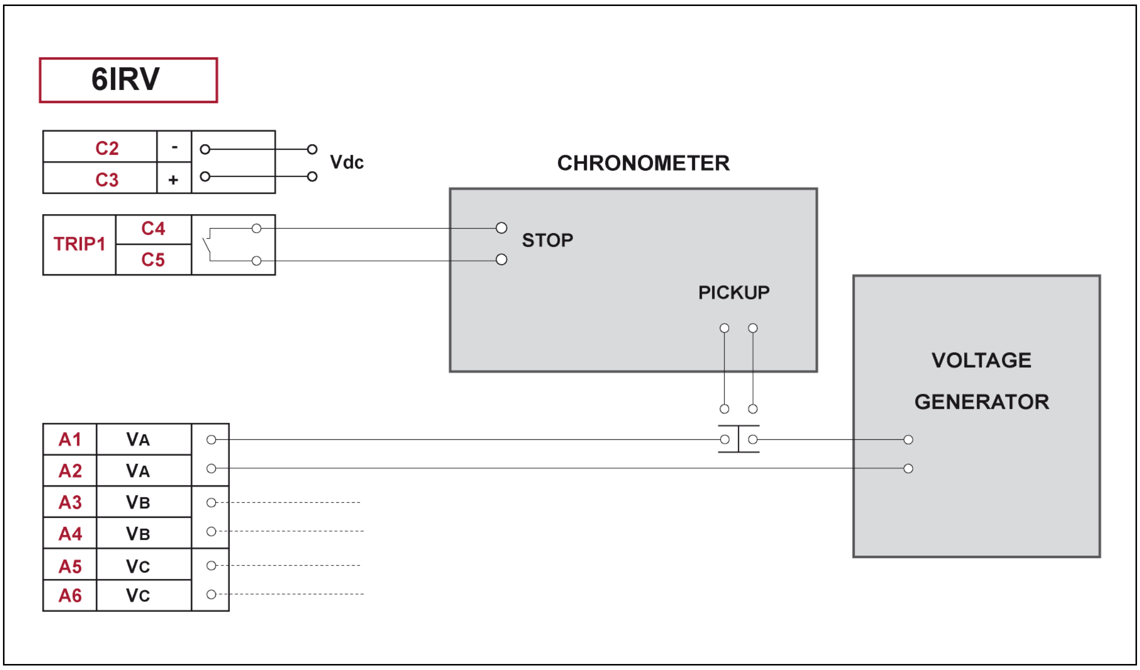


Figure 3.3.4: Operating Time Test Setup.

3.4 Frequency Elements

3.4.1 Introduction

6IRV IEDs have the following frequency elements:

- Three overfrequency elements (81M1, 81M2 and 81M3).
- Three underfrequency elements (81m1, 81m2 and 81m3).
- Three rate of change elements (81D1, 81D2 and 81D3).

The Underfrequency, Overfrequency and Rate of Change elements have their own settings for each function and a set of settings common to all of them. The shared settings are:

- **Inhibition Voltage**. This setting checks that the voltage is above a set value. If so, it allows the frequency elements to operate. Otherwise, the frequency elements are inhibited.
- **Activation Half-waves**. This is the number of half-waves that must meet the fault conditions for the frequency elements to pick up.
- **Reset Cycles**. This is the number of cycles during which there may not exist fault conditions so that the frequency elements already picked up will reset. When the frequency elements have been picked up and have not yet operated, the fault conditions may disappear during a brief instant. This setting indicates how long these conditions may disappear without resetting the element. For example, if the rate of change should be falling below -0.5 Hz/s and during an instant it only goes down to -0.45 Hz/s; it may not be desirable that the protection function reset if the time the fault condition disappears is very short.

All the elements have a disabling counter. This counter, of approximately 50 milliseconds, operates when, while the element is tripped, the function is deactivated either by the inhibition voltage, by setting or because the breaker opens.

All the elements have a time module that can be set to instantaneous. It has the following settings: **Pickup** and **Time**.

Figure 3.4.1 is the block diagram of one of the frequency elements.

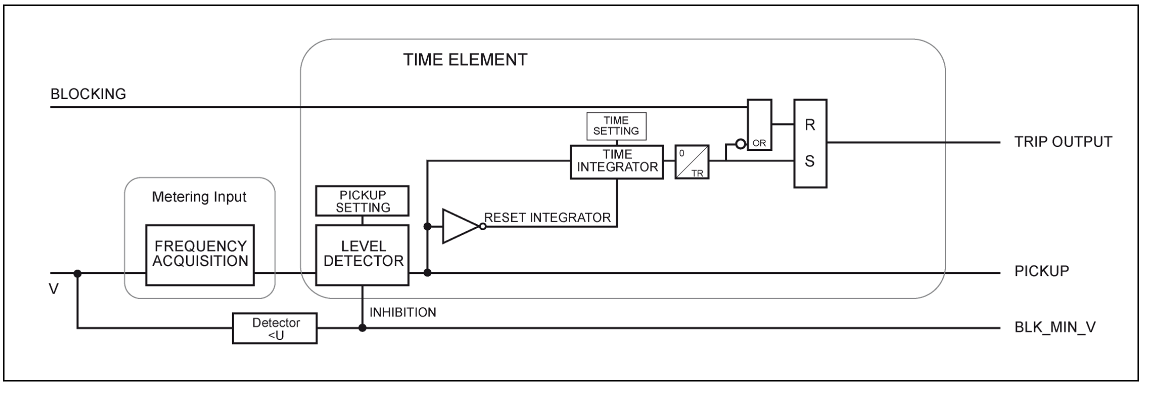


Figure 3.4.1: Block Diagram of a Frequency Element.

Associated with the level detection block, there is a setting for the pickup value: if the element is the overfrequency element, and the value measured exceeds the setting value a given quantity, the element picks up; if it is the underfrequency element, it picks up whether or not the value measured is less than the setting value a given quantity.

Activation of the pickup enables the timing function. This is done by applying increments on a meter that picks up the element when it times out.

3.4.2 Overfrequency Elements

The Overfrequency elements operate on the measured frequency value of voltages **Va**, **Vb** or **Vc**.

Pickup occurs when the value measured coincides with or surpasses the pickup value (100% of the setting) during a number of half-waves equal to or greater than the **Activation Half-Waves** setting, and resets when the frequency falls below 99.9% of this setting for a time equal to or greater than the **Reset Time** setting. This **Reset Time** setting indicates how long the fault conditions must disappear after a fault for the trip to reset.

3.4.3 Underfrequency Elements

Underfrequency elements operate on the measured frequency value of input voltages **Va**, **Vb** or **Vc**.

Pickup occurs when the value measured coincides with or is below the pickup value (100% of the setting) during a number of half-waves equal to or greater than the setting of **Activation Half-Waves**, and resets when the frequency goes up above 100.1% of this setting for a time equal to or greater than the **Reset Time** setting. The same as in the overfrequency element, this **Reset Time** setting indicates how long the fault conditions must disappear after a fault for the trip to reset.

3.4.4 Rate of Change Elements

Rate of Change elements operate on the measured frequency value of input voltage **Va**.

The algorithm of these elements uses the following specific settings for the Rate of Change function (in addition to the enabling permission of each of them):

- **Frequency Pickup**. Frequency value below which this magnitude must be to consider the rate of its change.
- **Rate of Change Pickup**. Instantaneous value of the rate of change in respect of the time for which the element is to pick up.
- **Timing**. Time during which the fault condition must remain for the element to activate.
- **Reset Time**. Time during which the fault conditions must disappear after a fault for the element to reset.

In the algorithm, the rate of change must be below a given adjustable value for a time equal to or greater than the **Activation Half-Waves** setting before the rate of change is taken into account. It is activated when the frequency is the same as or below the pickup setting, and resets when the frequency goes above 100.1% of this setting. This algorithm checks the frequency and the rate of change of the frequency separately. For the element to operate, the fault conditions must exist for both. See figure 3.4.2.

For the element to pick up, the dF/dT value has to be greater (setting + 0.05 Hz/s in absolute value) than the value of the **Rate of Change Pickup** setting during five cycles minus the set number of **Activation Half-Waves**. The five cycles are subtracted because, just as a complete cycle is needed to calculate the frequency, to calculate the rate of change, at least 5 cycles are needed.

If the value of the **Activation Half-Waves** setting is less than ten half-waves, five cycles will be used to generate the pickup of the rate of change element.

The following figure depicts the operation mode for the Rate of Change function:

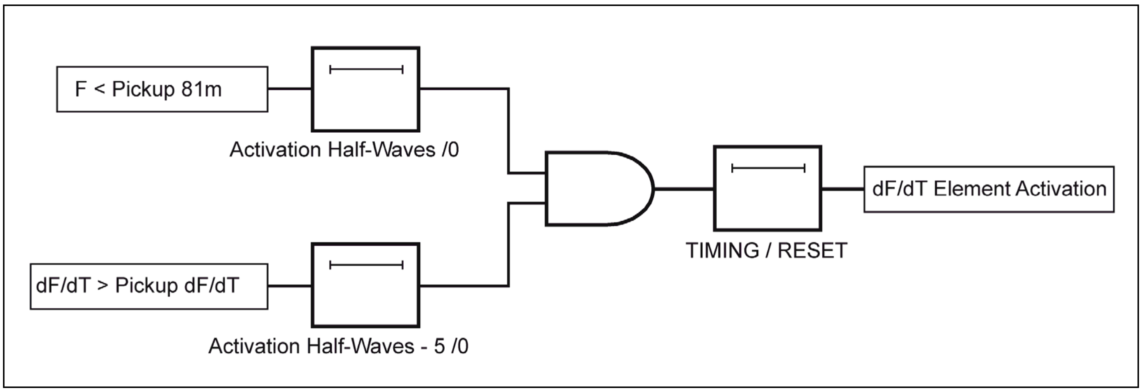


Figure 3.4.2: Algorithm of a Rate of Change Element.

3.4.5 Elements Blocking Logic

Each of the frequency elements has a **Blocking** logic input. Activating this input prevents the activation of the output of the corresponding frequency element, as shown in figure 3.4.1.

These logic input signals can be associated to the relay's status contact inputs by configuring the **Input** settings.

3.4.6 Undervoltage Unit for Blocking

This element supervises the functioning of the frequency elements, impeding their operation for measured voltage below the set value.

The element picks up when the measured voltage value coincides with or is less than the pickup value (100% of the setting), and resets with a value greater than or equal to 105% of the setting, provided this condition is maintained for at least 10 consecutive cycles. These 10 verification cycles provide assurance that the voltage is stable.

In any case, the relay cannot measure frequency for voltage less than 2 volts. Therefore, in these conditions, the frequency elements do not work.

3.4.7 Frequency Elements Settings

Common Settings			
Setting	**Range**	**Step**	**By default**
Inhibition for minimum voltage	2 - 150 V	1 V	40 V
Pickup time	3 - 30 half cycles	1 half cycle	6 half cycles
Dropout time	0 - 10 cycles	1 cycle	0 cycles

Overfrequency Elements 1, 2 and 3			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	40 - 70 Hz	0.01 Hz	70 Hz
Time delay	0.00 - 300 s	0.001 s	0 s
Dropout time	0.00 - 300 s	0.001 s	2 s

Underfrequency Elements 1, 2 and 3			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	40 - 70 Hz	0.01 Hz	40 Hz
Time delay	0.00 - 300 s	0.001 s	0 s
Dropout time	0.00 - 300 s	0.001 s	2 s

Rate of Change Elements 1, 2 and 3			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Frequency pickup	40 - 70 Hz	0.01 Hz	40 Hz
Rate of change pickup	(-10,00) - (-0,5) Hz/s	0.01 Hz/s	-1 Hz
Time delay	0.00 - 300 s	0.01 s	0 s
Dropout time	0.00 - 300 s	0.001 s	2 s

- **Frequency Protection: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**5 - FREQUENCY**
3 - INFORMATION	...	...

0 - FUSE FAILURE	**0 - INHIBIT VOLTAGE**
...	**1 - PICKUP TIME**
5 - FREQUENCY	**2 - DROPOUT TIME**
...	**3 - OVERFREQUENCY**
	4 - UNDERFREQUENCY
	5 - ROCOF

Overfrequency Protection

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - OVERFREQ. ENABLE**
1 - PICKUP TIME	**1 - UNIT 2**	**1 - OVERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3**	**2 - OVERFREQ. DELAY**
3 - OVERFREQUENCY		**3 - DROPOUT TIME**
4 - UNDERFREQUENCY		
5 - ROCOF		

Underfrequency Protection

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - UNDERFREQ. ENABLE**
1 - PICKUP TIME	**1 - UNIT 2**	**1 - UNDERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3**	**2 - UNDERFREQ. DELAY**
3 - OVERFREQUENCY		**3 - DROPOUT TIME**
4 - UNDERFREQUENCY		
5 - ROCOF		

Frequency Rate of Change

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - ROC FREQ. ENABLE**
1 - PICKUP TIME	**1 - UNIT 2**	**1 - UNDERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3**	**2 - ROCOF PICKUP**
3 - OVERFREQUENCY		**3 - ROC FREQ. DELAY**
4 - UNDERFREQUENCY		**4 - DROPOUT TIME**
5 - ROCOF		

3.4.8 Digital Inputs and Events of the Frequency Modules

Table 3.4-1: Digital Inputs and Events of the Frequency Modules		
Name	**Description**	**Function**
INBLK_OF1	Overfrequency element 1 block input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
INBLK_OF2	Overfrequency element 2 block input	
INBLK_OF3	Overfrequency element 3 block input	
INBLK_UF1	Underfrequency element 1 block input	
INBLK_UF2	Underfrequency element 2 block input	
INBLK_UF3	Underfrequency element 3 block input	
INBLK_ROC1	Rate of Change element 1 block input	
INBLK_ROC2	Rate of Change element 2 block input	
INBLK_ROC3	Rate of Change element 3 block input	
ENBL_OF1	Overfrequency element 1 enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_OF2	Overfrequency element 2 enable input	
ENBL_OF3	Overfrequency element 3 enable input	
ENBL_UF1	Underfrequency element 1 enable input	
ENBL_UF2	Underfrequency element 2 enable input	
ENBL_UF3	Underfrequency element 3 enable input	
ENBL_ROC1	Rate of Change element 1 enable input	
ENBL_ROC2	Rate of Change element 2 enable input	
ENBL_ROC3	Rate of Change element 3 enable input	

3.4.9 Digital Outputs and Events of the Frequency Modules

Table 3.4-2: Digital Outputs and Events of the Frequency Modules		
Name	**Description**	**Function**
PU_OF1	Overfrequency element 1 pickup	Pickup of the frequency elements and start of the time count.
PU_OF2	Overfrequency element 2 pickup	
PU_OF3	Overfrequency element 3 pickup	
PU_UF1	Underfrequency element 1 pickup	
PU_UF2	Underfrequency element 2 pickup	
PU_UF3	Underfrequency element 3 pickup	
PU_ROC1	Rate of Change element 1 pickup	
PU_ROC2	Rate of Change element 2 pickup	
PU_ROC3	Rate of Change element 3 pickup	
TRIP_OF1	Overfrequency element 1 trip	Trip of the frequency elements.
TRIP_OF2	Overfrequency element 2 trip	
TRIP_OF3	Overfrequency element 3 trip	
TRIP_UF1	Underfrequency element 1 trip	
TRIP_UF2	Underfrequency element 2 trip	
TRIP_UF3	Underfrequency element 3 trip	
TRIP_ROC1	Rate of Change element 1 trip	
TRIP_ROC2	Rate of Change element 2 trip	
TRIP_ROC3	Rate of Change element 3 trip	

Table 3.4-2: Digital Outputs and Events of the Frequency Modules

Name	Description	Function
OF1_ENBLD	Overfrequency element 1 enabled	Enable or disable status indication of the frequency elements.
OF2_ENBLD	Overfrequency element 2 enabled	
OF3_ENBLD	Overfrequency element 3 enabled	
UF1_ENBLD	Underfrequency element 1 enabled	
UF2_ENBLD	Underfrequency element 2 enabled	
UF3_ENBLD	Underfrequency element 3 enabled	
ROC1_ENBLD	Rate of Change element 1 enabled	
ROC2_ENBLD	Rate of Change element 2 enabled	
ROC3_ENBLD	Rate of Change element 3 enabled	
BLK_MIN_V	Minimum voltage block	Blocking of frequency and phase angle measuring units.
INBLK_OF1	Overfrequency element 1 block input	The same as for the Digital Inputs.
INBLK_OF2	Overfrequency element 2 block input	
INBLK_OF3	Overfrequency element 3 block input	
INBLK_UF1	Underfrequency element 1 block input	
INBLK_UF2	Underfrequency element 2 block input	
INBLK_UF3	Underfrequency element 3 block input	
INBLK_ROC1	Rate of Change element 1 block input	
INBLK_ROC2	Rate of Change element 2 block input	
INBLK_ROC3	Rate of Change element 3 block input	
ENBL_OF1	Overfrequency element 1 enable input	The same as for the Digital Inputs.
ENBL_OF2	Overfrequency element 2 enable input	
ENBL_OF3	Overfrequency element 3 enable input	
ENBL_UF1	Underfrequency element 1 enable input	
ENBL_UF2	Underfrequency element 2 enable input	
ENBL_UF3	Underfrequency element 3 enable input	
ENBL_ROC1	Rate of Change element 1 enable input	
ENBL_ROC2	Rate of Change element 2 enable input	
ENBL_ROC3	Rate of Change element 3 enable input	

3.4.10 Frequency Elements Test

Before testing these units, the voltage units that are not being tested must be disabled.

- **Pickup and Reset of the Overfrequency and Underfrequency Elements**

Depending on the settings of the frequency units (overfrequency / underfrequency), the pickups and resets must be within the margins indicated in table 3.4-3 for their rated voltage.

Table 3.4-3:Pickup and Reset of the Overfrequency and Underfrequency Elements

Setting	Pickup		Reset	
	ΦA_MIN	ΦA_MAX	ΦR_MIN	ΦR_MAX
XHz	X±0.005Hz	(Xx0.999)±0.005Hz	X±0.005Hz	(Xx1.001)±0.005Hz

- **Voltage Reset**

The frequency units must reset within the margin indicated in Table 3.4-4 for set voltage value X.

Table 3.4-4:Voltage Reset

Min. Voltage Setting	Reset	
	VR_MIN	VR_MAX
X	0.95 • X	1.05 • X

- **Operating Times**

They are verified with trip outputs C4-C5.

To measure times, the voltage generator must be able to generate an up or down frequency ramp depending on the unit to be tested as well as to provide an output to initiate a chronometer when it gets to the pickup frequency.

Operating times for a setting of Xs must be between (1.01 × X – 0.99 × X) or between (X+20 ms - X-20 ms). If the setting is 0, the operating time will be close to 60 ms.

In operating times, it is important how the frequency ramp is generated and when the chronometer starts. The frequency value of the signal generated should be very close to the threshold to test and generate the broadest step possible.

Without a frequency ramp generator, only the maximum frequency unit can be tested. Going from no voltage applied to applying voltage above the disable and the maximum frequency settings will yield a time value somewhat greater than with a frequency ramp.

- **Pickup and Reset of the Rate of Change Elements**

The Rate of Change elements are configured with the following operation values:

81D1 Element	**0.5 Hz/s**
81D2 Element	**0.7 Hz/s**
81D3 Element	**0.9 Hz/s**

They are all set to the same frequency value.

Frequency ramps are generated below the set frequency value and each ramp must operate with a margin of error not greater than 0.05 Hz/s.

3.5 Open Phase Unit

3.5.1 Operating Principles

The Open Phase unit is for the purpose of detecting series faults, which may occur due to the rupture of an overhead line conductor. A series fault generates an unbalanced condition which can be detected by measuring the negative sequence current (I2). The overcurrent units incorporated in the **6IRV** which use this magnitude should present pick up levels above the maximum unbalance which may arise in the line under normal conditions (without fault). This unbalance will be greater the more unbalanced the line, such that, in a maximum load condition, the negative sequence current may come to be in the neighborhood of that corresponding to a series fault. This would impede the negative sequence overcurrent units from detecting this type of fault. The open-phase unit uses the negative sequence (I2) as well as the positive sequence (I1) current and operates based on the (I2/I1) ratio, thus making its operation independent from the line load.

The pick up of the unit occurs when this ratio exceeds the setting startup value. Figures 3.5.1, 3.5.2 and 3.5.3 represent the block diagram of this unit.

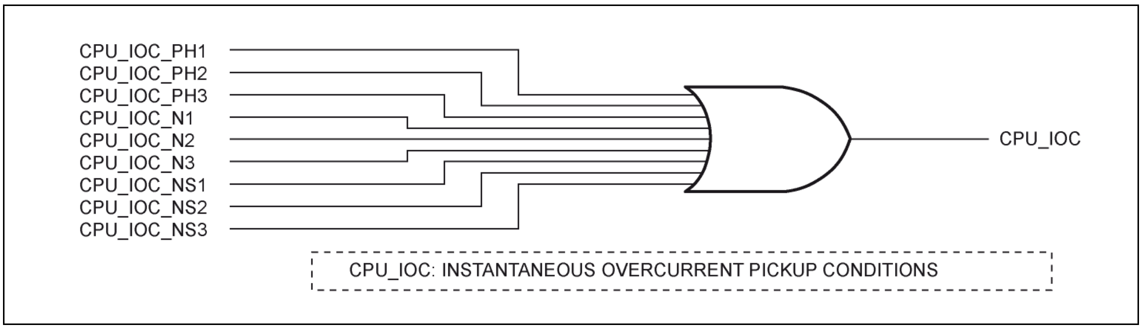


Figure 3.5.1: Activation Logic of the Pick Up Condition Signal of the Instantaneous Overcurrent Elements Used by the Open Phase.

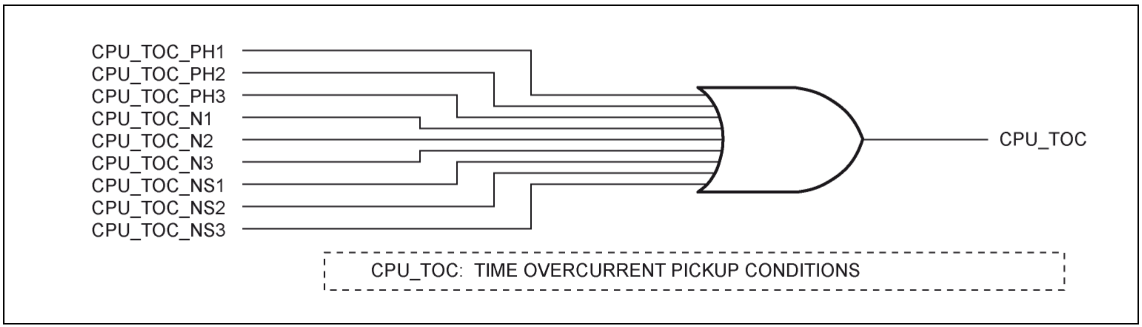


Figure 3.5.2: Activation Logic of the Pick Up Condition Signal of the Time Overcurrent Elements Used by the Open Phase.

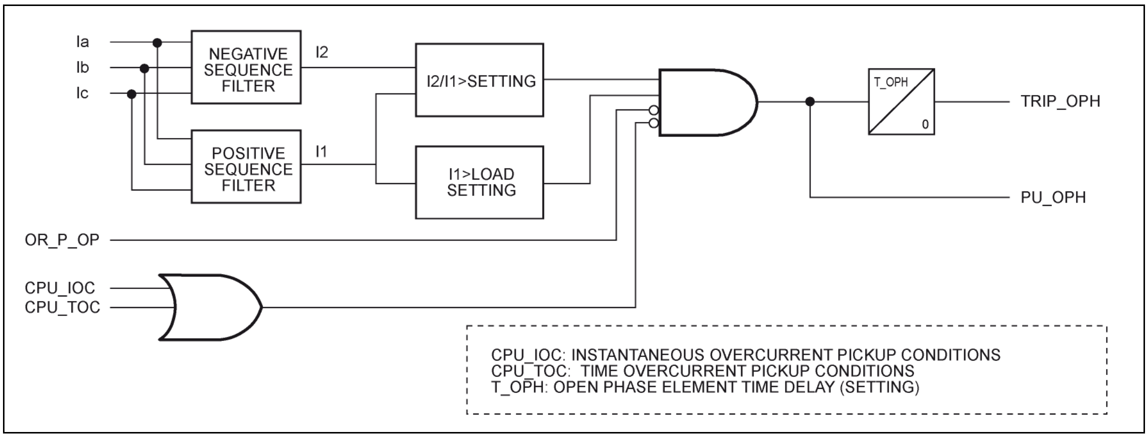


Figure 3.5.3: Block Diagram of the Open-Phase Unit.

Once picked up, the element acts if the pickup is maintained for a period of time equal to or greater than the set value.

The operation of this function is conditioned to the position of the breaker and to the level of the positive sequence current: if any breaker pole (**OR_P_OP**) is open or the positive sequence current is less than the **Positive Sequence Sensitivity** setting, the unit will be disabled. Similarly, the function will be cancelled when there is a pick up of any of the distance elements or a pick up condition (without considering the directionality) of any of the overcurrent elements: phase, ground or sequence time or instantaneous. In this manner, the actuation of the open phase unit is only ensured in case of series faults.

When the aperture of a single pole of the breaker is produced (single-phase or transient reclose sequence in a three-phase trip in which the three poles do not open at the same time), an unbalanced condition similar to that of a series fault will be originated. The **Any Pole Open** (**OR_P_OP**) signal allows to detect the previous condition and blocks the open phase unit. Notwithstanding, the relay will always measure a negative sequence current before activating the **OR_P_OP** signal. This measured current may cause the open phase unit to pick up before it receives the blocking signal, for which it is necessary to establish a minimum timing.

Pick up occurs when the value measured exceeds 1.02 times the pickup setting and resets at 0.97 times the pickup setting.

3.5.2 Open Phase Unit Settings

Open Phase Unit			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup I2 = Negative Sequence Current I1 = Positive Sequence Current	0.05 - 0.4 I2/I1	0.01	0.05
Minimum Load Open Phase	(0.02 - 1) In	0.01 A	0.1 In
Time Delay	0.05 - 300 s	0.01 s	0.05

- **Open Phase Unit: HMI Access**

0 - CONFIGURATION		0 – FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**6 - OPEN PHASE DETECTOR**
3 - INFORMATION	…	…

0 – FUSE FAILURE	**0 - OPEN PHASE ENABLE**
…	**1 - OPEN PHASE PU**
6 - OPEN PHASE DETECTOR	**2 - OPEN PHASE WAIT TIME**
…	**3 - MIN. LOAD OPEN PHASE**

3.5.3 Digital Inputs and Events of the Open Phase Module

Table 3.5-1: Digital Inputs and Events of the Open Phase Module		
Name	**Description**	**Function**
ENBL_OPH	Open phase detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

3.5.4 Digital Outputs and Events of the Open Phase Module

Table 3.5-2: Digital Outputs and Events of the Open Phase Module		
Name	**Description**	**Function**
PU_OPH	Open phase detector pickup	Pickup of the time count element.
TRIP_OPH	Open phase detector trip	Trip of the element.
OPH_ENBLD	Open phase detector element enabled	Indication of enabled or disabled status of the detector.
ENBL_OPH	Open phase detector enable input	The same as for the Digital Input.

3.5.5 Open Phase Element Test

After putting all the phase and ground units out of service, this two-current system is applied:

Ia = 1/0º and Ib = 1/60º (it is understood that these angles are inductive).

After setting the element to 0.2 I2/I1, it must not be picked up. After increasing the phase B current, the element must pick up (the pickup flag at "1") with a current value in phase B between 1.493 Aac and 1.348 Aac.

With the trip time set to 10 s, a current of 2 A / 60º is applied in phase B. A trip must be initiated between 10.1 s and 9.9 s. Also the trip contacts must close.

In model **6IRV**, the unit is set to 0.2 I1/I1.2 and the **Minimum Load** in the line to 1.2 A. Applying Ia = 1/0º and Ib = 2/60º, the unit should not operate. If, under the same conditions, the **Minimum Load** in the line is set to 0.8 A, the unit should pick up.

3.6 Thermal Image Unit

3.6.1 Operating Principles

Thermal relays, which directly measure the temperatures of the machine to be protected, have very serious problems in accomplishing their function in more sensitive areas (windings), having to take measurements in nearby areas (oil, insulators, etc.). This indirect measurement involves drawbacks because the points where the direct temperature measurements are made belong to elements with significant thermal inertia.

For this reason, instead of using thermal relays, thermal image protections are commonly used. Using mathematical algorithms based on the material's physics, they estimate the temperature of the machine to be protected using the currents that flow through the machine.

It is assumed that when machine overloads occur, the main cause for deterioration is the thermal phenomenon; possible dynamic effects are not considered.

6IRV protection terminals have a thermal image protection unit that estimates the thermal state by measuring the current flow and resolving the thermal differential equation in order to generate a trip when high temperature levels are reached.

The algorithms are based on modeling the heating of a resistive element when running an electric current through it. The effect of radiation is not considered (since the impact is considered negligible given the temperatures reached by the elements to be protected, less than 400 ºC), nor are heat dissipation sources other than that deriving from the Joule effect.

Cooling of the equipment is also simulated if the current value returns to the rated range after a relatively short overload period.

The thermal image unit does not have a threshold at which pickup starts: it is always "picked up". The trip time depends on the current flowing from a given instant up to when the temperature limit is reached and the temperature value at a specific instant. The prior temperature depends on what has happened before, the measured current and the time applied.

The differential equation that controls any thermal phenomenon is the following:

$$I^2 = \theta + \tau \cdot \frac{d\theta}{dt}$$

Where:

I:	Is the RMS value of the measured current.
τ:	Is the time constant. Adjustable parameter.
Imax:	Value of the maximum admissible sustained current. Adjustable parameter.

The Time Constant is represented by τ and it represents the time needed for a body that will go from an initial temperature θ_0 to a final temperature θ_∞ to reach 63% of the temperature increase necessary for θ_∞; that is, the time it will take to reach the intermediate temperature θ_i starting from θ_0, where:

$\theta_i = \theta_0 + (\theta_\infty - \theta_0) * 0.63$

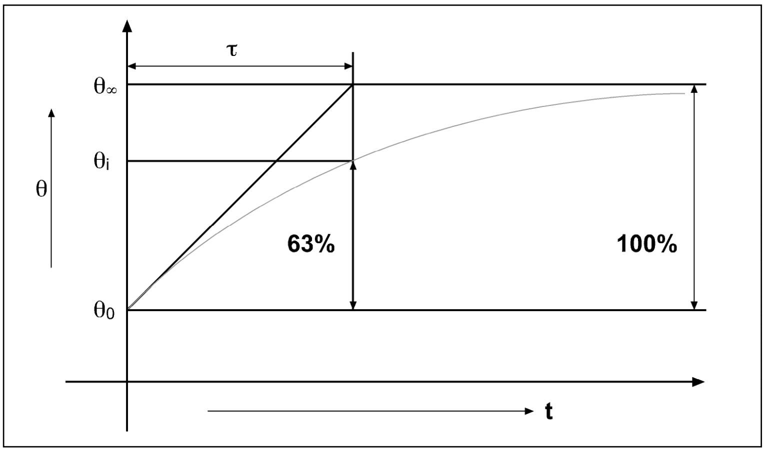


Figure 3.6.1: Time Constant (Thermal Image).

Temperature values (θ) are always stored in case there is a failure in the IED's power supply. There is a **Thermal Memory** setting that you can set to **YES** so that the initial temperature value will be the stored one whenever the IED is reinitialized.

This unit is prepared to protect lines from overheating. For lines, the rated voltage used is the sum of the square of phase A. It has two time constants, one for heating (while there is current) and one for cooling (when the positive sequence current is under 0.1 amperes).

The thermal image unit estimates the thermal state and, when it reaches the level equivalent to that obtained by the constant flow of Imax, it provides a trip output.

In addition to the trip level, the unit has an adjustable alarm level.

The thermal state is estimated thus:

- The initial value is $\theta = 0$ or $\theta \neq 0$ depending on the initial thermal state.
- The thermal image unit is activated every 500 milliseconds. Each time, it subtracts the θ value of the preceding sample from the current value squared:
  A = I^2 - θ
- The value obtained is divided by the time constant and multiplied by 500 milliseconds:
  B = A * (0.5 sec / τ (in sec))
- This value is added to the preceding θ to obtain the current.
  $\theta = \theta + B$

The value of θ is calculated as a % of the maximum value.

The **Thermal Image Trip** output is activated when the corresponding θ value reaches the value:

$$\theta_{TRIP} = Imax^2$$

The **Thermal Image Trip** signal resets when θ descends below:

$$\theta_{RST\_TRIP} = \theta_{TRIP} * PermissionSetting\_Connection\ (\%) / 100$$

The **Thermal Image Alarm** output is activated when the θ value reaches the value:

$$\theta_{ALARM} = \theta_{TRIP} * AlarmSetting\ (\%) / 100$$

The **Thermal Image Alarm** signal resets when θ descends below:

$$\theta_{RST\_ALARM} = 0.95 * \theta_{ALARM}$$

After applying a current **I** and starting with a current value of zero, the trip time is:

$$t = \tau \cdot Ln \frac{I^2}{I^2 - Imax^2}$$

If you start with a preliminary **Ip** current level, the operating time is:

$$t = \tau \cdot Ln \frac{I^2 - Ip^2}{I^2 - Imax^2}$$

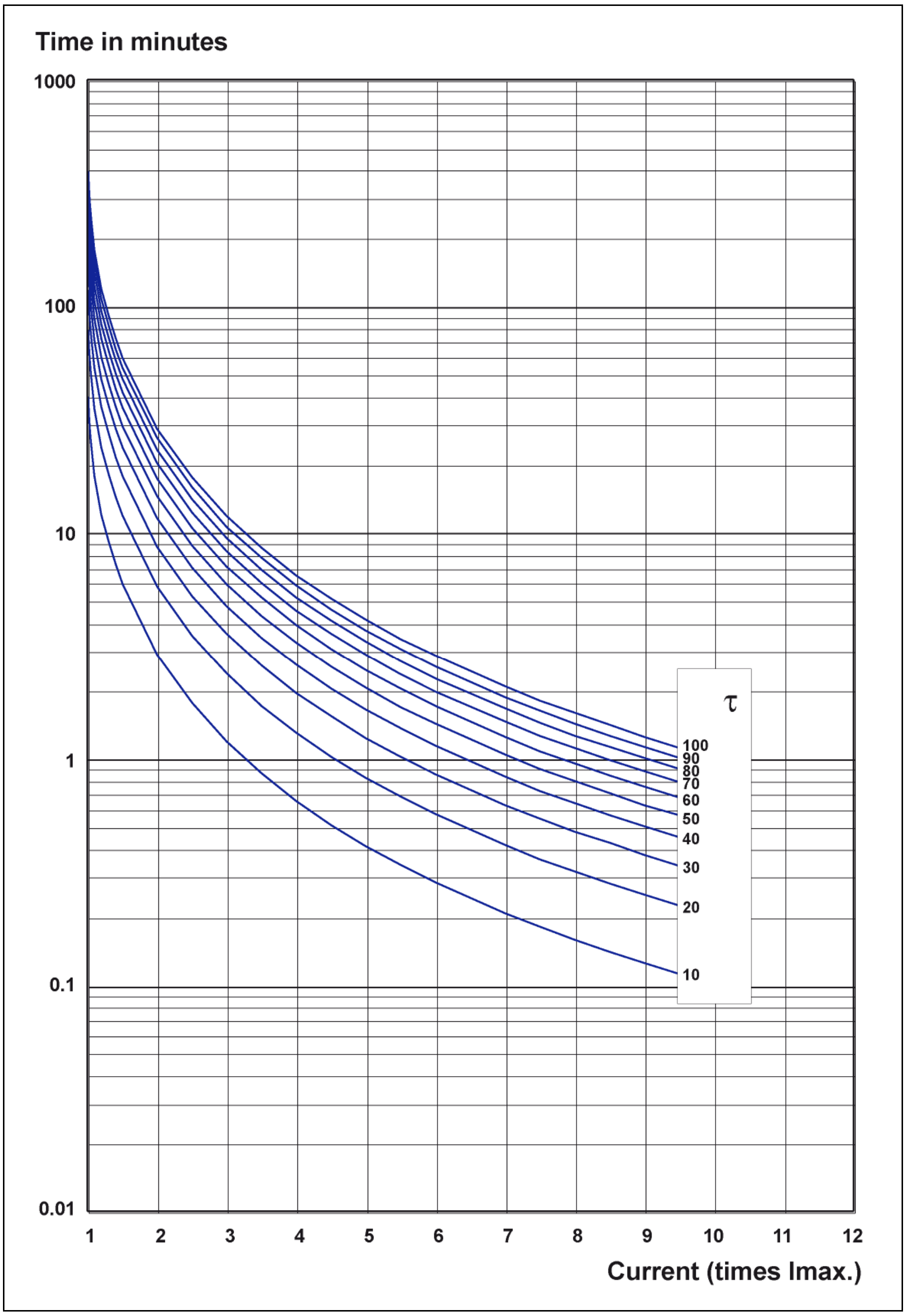


Figure 3.6.2: Operating Time Curves of the Thermal Image Unit.

3.6.2 Thermal Image Unit Settings

Thermal Image Unit			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Heating constant ζ 1	0.5 - 300 min	0.01 min	0.5 min
Cooling constant ζ 2	0.5 - 300 min	0.01 min	0.5 min
Maximum sustained current	(0.2 - 2.5) In	0.01A	In
Alarm activation level	50 - 100%	1%	50%
Reset threshold	5 - 100%	1%	80%
Thermal memory enable	YES / NO		NO

- **Thermal Image Unit: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**9 - THERMAL IMAGE**
3 - INFORMATION	...	...

0 - FUSE FAILURE	**0 - THERMAL IMG. ENA**
...	**1 - CONSTANT 1**
9 - THERMAL IMAGE	**2 - CONSTANT 2**
...	**3 - MAX. SUST. CURR.**
	4 - ALARM LEVEL
	5 - RESET THRESHOLD
	6 - THERMAL MEMORY

3.6.3 Digital Inputs and Events of the Thermal Image Module

Table 3.6-1: Digital Inputs and Events of the Thermal Image Module		
Name	**Description**	**Function**
RST_MEM_T	Thermal image reset	Its activation resets the memorized value.
INBLK_THERM	Thermal image blocking input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
ENBL_THERM	Thermal image enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."

3.6.4 Digital Outputs and Events of the Thermal Image Module

Table 3.6-2: Digital Outputs and Events of the Thermal Image Module		
Name	**Description**	**Function**
AL_THERM	Thermal image alarm	Alarm of the thermal image unit.
TRIP_THERM	Thermal image trip	Trip of the thermal image unit.
THERM_ENBLD	Thermal image enabled	Indication of enabled or disabled status of the unit.
RST_MEM_T	Thermal image reset	The same as for the Digital Input.
INBLK_THERM	Thermal image blocking input	The same as for the Digital Input.
ENBL_THERM	Thermal image enable input	The same as for the Digital Input.

3.6.5 Thermal Image Unit Test

Before performing this test, the protection should be turned off and then back on to reset the thermal level. A current greater than the set maximum sustained current (I_{max}) is applied through phase A. The trip time must be:

$$t = \tau \cdot Ln \frac{(I \pm 1\%)^2}{(I \pm 1\%)^2 - Imax^2}$$

where τ is the set time constant ζ1.

An example: a time constant of 0.5 minutes and a maximum current of 5 A. A current of 6 A is injected in phase A of the first winding. The time transpired until the thermal unit trips must be between 33.05 s and 38.18 s.

3.7 Breaker Failure Unit

3.7.1 Introduction

The **6IRV** models incorporate one or two Breaker Failure elements (depending on the model). The Breaker Failure unit detects malfunction of the breaker after a trip command is issued. A signal is generated to allow closing of other breakers contributing to the fault (those adjacent to that protected line and at the remote end).

The Breaker Failure unit incorporates a retrip function whose objective is to send a new tripping command to the failed breaker before the open command directed toward the remaining breakers which may continue to feed the fault is generated. In order for the failed breaker to open with the retripping command before being actuated over the breakers of the adjacent lines, the timing of the breaker failure unit should be longer than that adjusted in the retrip function.

The Breaker Failure protection is provided with six phase current metering units, two for each of the phases, and one ground current metering unit. The two groups of phase metering units and the ground metering unit have independent pick up levels, with the following settings: **Phase Single-Phase Pick Up** (1 phase pick up), **Phase Three-Phase Pick Up** (2 phase pick up) and **Ground Pick Up**.

The main characteristic of the pick up detectors is its rapid reset time (5 ms).

The diagrams corresponding to the measuring units are those represented in Figures 3.7.1 and 3.7.2 and give the breaker failure pick up signals as the output.

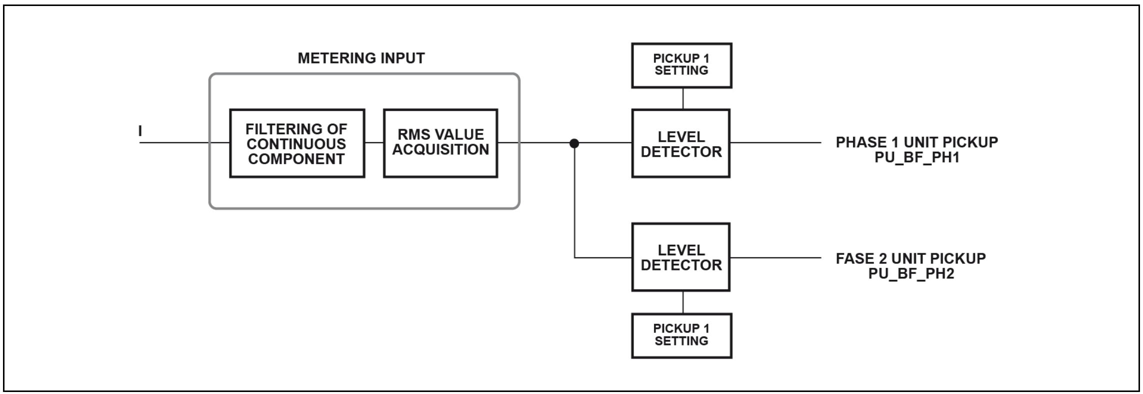


Figure 3.7.1: Block Diagram of the Phase Current Metering Units of the Breaker Failure.

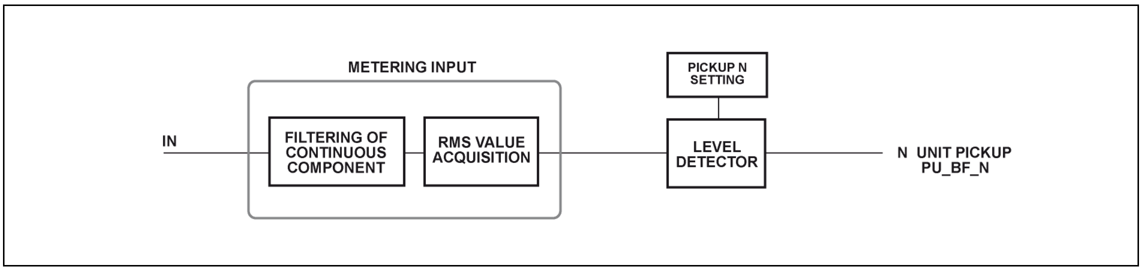


Figure 3.7.2: Block Diagram of the Ground Current Metering Unit of the Breaker Failure.

3.7.2 Operation Logic of the Breaker Failure Unit. 6IRV-A Model

The operation logic of the Breaker Failure unit for **6IRV-A** models is described in the following. This logic is controlled by the pick up of the above-mentioned phase and ground overcurrent units together with a series of logic signals originating from other protection modules.

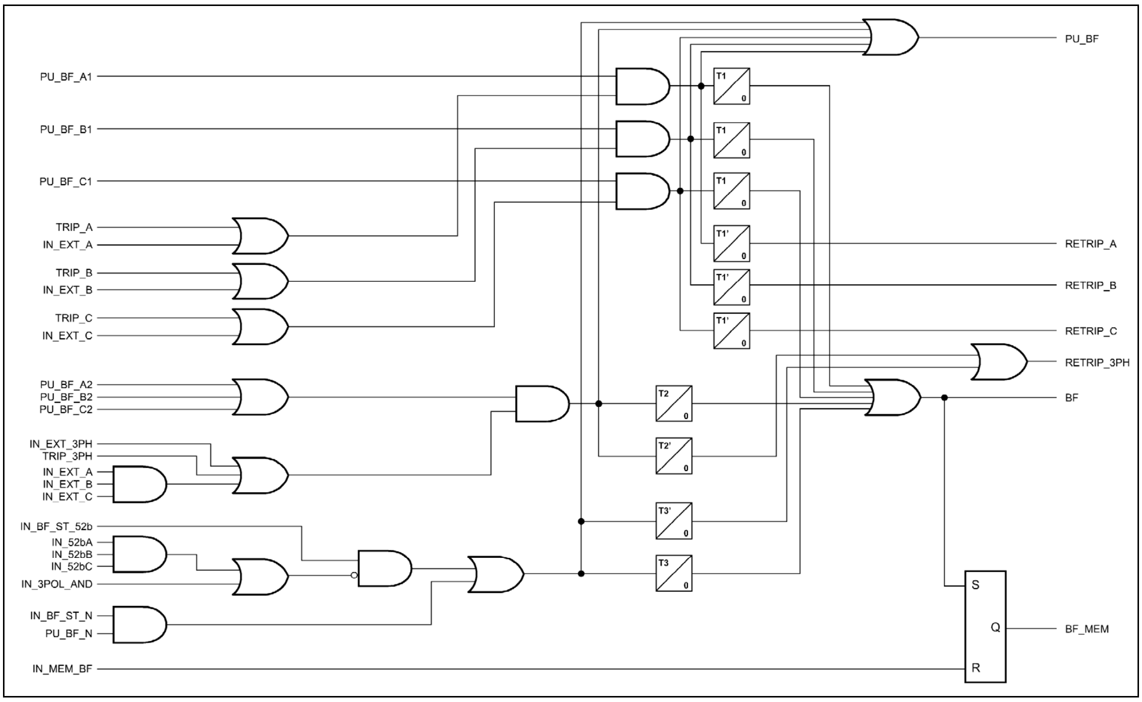


Figure 3.7.3: Logic Diagram of the Breaker Failure Unit (6IRV-A Model).

The actuation of the Breaker Failure unit (activation of the **BF** output) is memorized in a bistable element, activating the **BF_MEM** output. This signal will remain active even when **BF** is reset and only disappears through a reset command which will be issued through the activation of the **IN_MEM_BF** logic input.

The actuation process of the breaker failure unit can be divided into three groups: **Single-Phase Tripping**, **Three-Phase Tripping with Phase Overcurrent** and **Three-Phase Tripping without Phase Overcurrent**.

3.7.2.a Single-Phase Tripping

The commencement of the single-phase breaker failure is produce by the activation of a single-phase tripping signal together with the pick up of the single-phase current detector associated with the tripped phase (faulted phase). The single-phase trip signals may be originate from an external unit (**A Pole External Trip** (**IN_EXT_A**), **B Pole External Trip** (**IN_EXT_B**) and **C Pole External Trip** (**IN_EXT_C**) logic inputs).

The starting of the single-phase breaker failure starts the **T1** timers (**Single-Phase Breaker Failure Time**) and **T1’** (**Single-Phase Retripping Time**). The **T1’** timer output generates the retripping signal associated with the faulted phase -**A Pole Retripping** (**RETRIP_A**), **B Pole Retripping** (**RETRIP_B**), **C Pole Retripping** (**RETRIP_C**)-, in order to send a new tripping command to the failed breaker pole, before generating the **Breaker Failure** (**BF**) command. If the retripping command does not produce the aperture of the pole already tripped, the **T1** timer will reach the end, activating the **BF** (**Breaker Failure**) and **BF_MEM** (**Memorized Breaker Failure**) signals. The use of timers segregated by phase ensures the expiration of the **T1** time before the activation of the breaker failure output in the event of evolving faults.

As was indicated previously, the most important characteristic of the current detectors is their rapid reset time, in order to stop the timer count as soon as the breaker opens and make the current disappear, not allowing the erroneous activation of **BF**. If the reset time is long, there is a risk of not stopping the timer in time, in spite of the disappearance of current, and cause the undue tripping of other breakers not belonging to the protected line.

3.7.2.b Three-Phase Tripping with Phase Overcurrent

The starting of the three-phase trip failure with overcurrent is produced by the activation of a three-phase trip signal together with the pick up of any of the three-phase current detectors. The three-phase trip signal can be generated by the equipment itself (**Three-Phase Tripping** (**TRIP_3PH**), originating from the Single/Three-Phase Trip Logic, see 3.17) or by an external unit (AND logic output of **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C** or activation of **IN_EXT_3PH**).

The starting of the three-phase breaker failure with overcurrent starts the **T2** (**Three-Phase Breaker Failure Time**) and **T2’** (**Three-Phase Retripping Time**) timers. The **T2’** timer output generates the **Three-Phase Retripping** (**RETRIP_3PH**) signal in order to send a new trip command to the failed breaker, before generating the **Breaker Failure** (**BF**) command. If the retrip command does not produce the breaker aperture, the **T2** timer will reach the end, activating the **BF** (**Breaker Failure**) and **BF_MEM** (**Memorized Breaker Failure**) signals.

Given that polyphase faults require to be cleared more quickly than single-phase faults, in order to ensure the stability of the system, the **T2** time will be adjusted to a lower value than the **T1** time. Thus, when the trip is three phase, the breaker failure signal will always be activated on expiration of **T2** instead of **T1**.

The rapid reset time of the current detectors should again be pointed out.

3.7.2.c Three-Phase Tripping without Phase Overcurrent

The trip signals, of the equipment itself or of an external unit, which produce the commencement of a breaker failure, can be activated without the pick up of the phase current detection units. This situation may arise, in general, in case of any type of disturbance tripped by units which do not depend on the current metering, such as Voltage units, Frequency, etc., or in case of faults in which the local contribution is very weak, as a result of the fault resistance being very high or the local source being weak.

There are two alternative routes to detect a breaker failure without overcurrent:

- **Detection Based on the Position of the Breaker Contacts**

The start of the Breaker Failure is produced with the activation of the **Contact Position Breaker Failure Start** (**IN_BF_ST_52b**) whenever any breaker pole remains closed (it is checked either that the AND of the three breaker position inputs is open (**IN_52bA**, **IN_52bB** and **IN_52bC**), deactivated or that the input of three open poles (**IN_3POL_AND**) is set at zero). The input can be configured with the trip outputs of the Frequency units, Overvoltage, etc.

- **Detection Based on a Ground Current Metering Unit**

The start of Breaker Failure is produced with the activation of the **IN_BF_ST_N** (**Ground Unit Breaker Failure Start** input) input together with the starting of the ground current detector. The **IN_BF_ST_N** input can be configured with the general tripping output of the equipment (**TRIP**) or with an external general tripping output (**IN_EXT** or OR of **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C**).

The start of the three-phase breaker failure without phase overcurrent starts the **T3** (**Three-Phase Breaker Failure Time without Overcurrent**) and **T3'** (**Three-Phase Retripping Time without Overcurrent**) timers. The **T3'** timer generates the **Three-Phase Retripping** (**RETRIP_3PH**) signal in order to send a new trip command to the failed breaker, before generating the **Breaker Failure** (**BF**) command. If the retrip command does not produce the aperture of the breaker, the **T3** timer will reach the end, activating the **BF** (**Breaker Failure**) and **BF_MEM** (**Memorized Breaker Failure**) signals.

3.7.3 Operation Logic of the Breaker Failure Unit. 6IRV-B Model

In breaker and a half or ring configurations, it must be discerned which of the breakers associated to a given bay has failed, as the actions to be taken differ as a function of the failed breaker. Thus, two breaker failure elements are necessary, which will operate based on the current circulating through each breaker and not through the line (sum of both currents).

6IRV-B relays incorporate two breaker failure elements, designated element 1 and element 2, to supervise breakers 1 and 2 respectively. Phase and ground elements associated to breaker 1 will operate based on currents measured by channels IA-1, IB-1, IC-1 and the calculated current IN-1, respectively, while elements associated to breaker 2 will operate based on currents measured by channels IA-2, IB-2, IC-2 and calculated current IN-2. **6IRV-B** relay operation logic associated to element n (n=1, 2) is shown below.

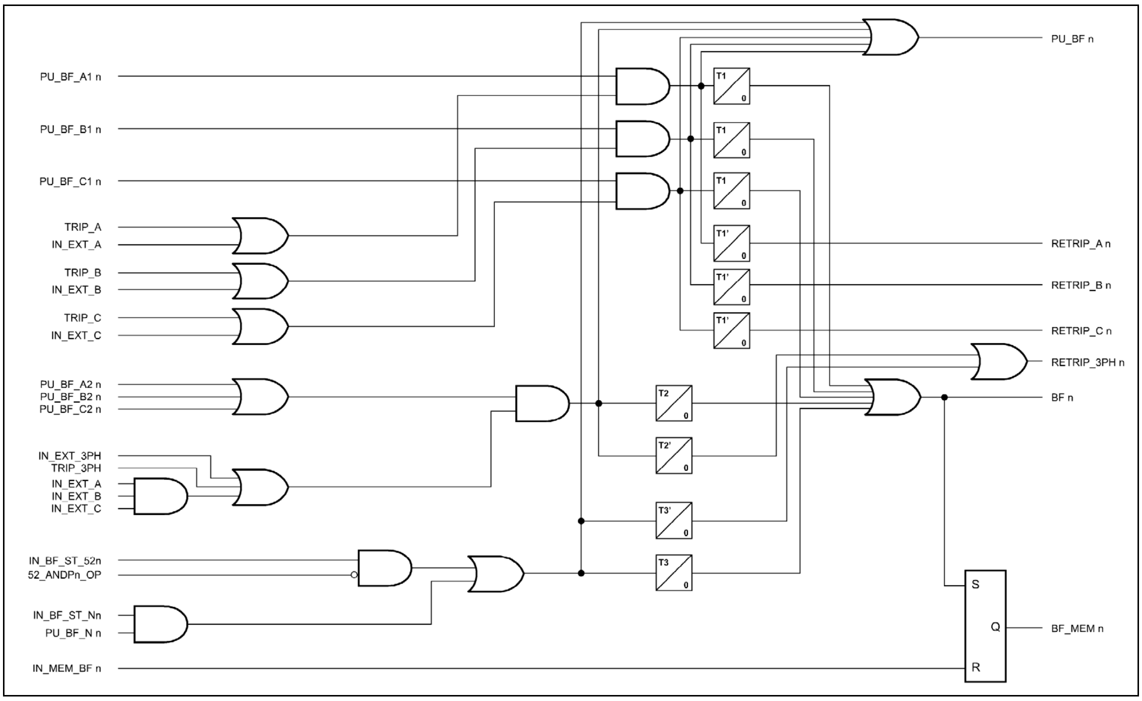


Figure 3.7.4: Logic Diagram of Breaker Failure Element (6IRV-B Model).

3.7.4 Internal Arc Detector

As a complement to the above-mentioned Breaker Failure unit, the **6IRV** equipment incorporates a logic which allows to detect the existence of an unextinguished internal arc. **6IRV-B** relays incorporate two internal arc detectors, one per breaker, which will use the supervised breaker pole state inputs.

If a breaker begins to open but remains jammed, the electric arc between the contacts may not be extinguished. The arc resistance may greatly reduce the fault current to the point of resetting the protection units and the trip signal. In this case, the Breaker Failure unit would also be reset.

The presence of an unextinguished electric arc in a phase can be detected if the pole position contacts associated with that phase indicate that this is open and notwithstanding the current in this phase exceeds a determined threshold (**Internal Arc Detector Pick Up** setting).

The pick up of the Internal Arc Detector tends to adjust to below the pick up values of the current metering units used by the Breaker Failure function. The operation diagram of the Internal Arc Detector is shown to the right.

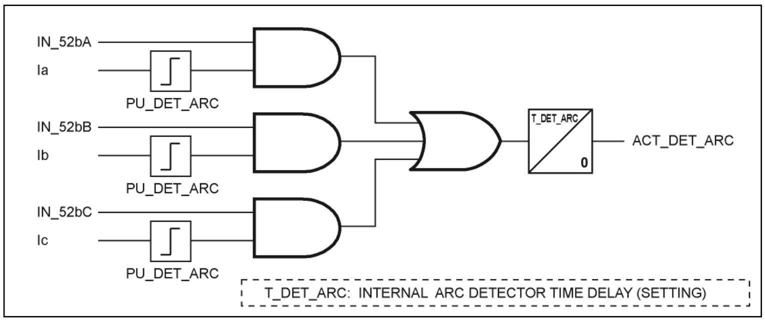


Figure 3.7.5: Logic Diagram of the Internal Arc Detector.

3.7.5 Breaker Failure Unit Settings

Breaker Failure Unit			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Single-phase pickup	(0.02 - 2.4) In A	0.01 A	0.2 In
Three-phase pickup	(0.02 - 2.4) In A	0.01 A	0.2 In
Ground pickup	(0.02 - 1.2) In A	0.01 A	0.1 In
Single-phase breaker failure time delay	0.05 - 2 s	0.01 s	0.5 s
Three phase breaker failure time delay with overcurrent	0.05 - 2 s	0.01 s	0.5 s
Three phase breaker failure time delay without overcurrent	0.05 - 2 s	0.01 s	0.5 s
Single-phase breaker failure retripping time delay	0.05 - 2 s	0.01 s	0.5 s
Three-phase breaker failure retripping time delay with overcurrent	0.05 - 2 s	0.01 s	0.5 s
Three-phase breaker failure retripping time delay without overcurrent	0.05 - 2 s	0.01 s	0.5 s
Internal arc detector enable	YES / NO		NO
Internal arc detector pickup	(0.01 - 0.2) In A	0.01 A	0.01 In
Internal arc detector time delay	0.1 - 2 s	0.01 s	0.1 s

- **Breaker Failure Unit: HMI Access**

6IRV-A MOD.

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**11 - BREAKER FAILURE**
3 - INFORMATION	….	…

0 - FUSE FAILURE	**0 - BF ENABLE**
…	**1 - SINGLE PHASE PU**
11 - BREAKER FAILURE	**2 - THREE PHASE PU**
…	**3 - BF GROUND PICKUP**
	4 - 1 POLE BF DELAY
	5 - 3 POLE BF DELAY
	6 - 3POLE NOOC BF DLY
	7 - 1 POLE RETRIP DELAY
	8 - 3 POLE RETRIP DELAY
	9 - 3POLE RETRP NOOC DLY
	10 - ARC DET ENABLE
	11 - ARC DETEC PICK UP
	12 - ARC DETECTOR TIME

6IRV-B MOD.

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**12 - BREAKER FAILURE**
3 - INFORMATION	….	…

0 - FUSE FAILURE		**0 - BF ENABLE**
…	**0 - BREAKER 1**	**1 - SINGLE PHASE PU**
12 - BREAKER FAILURE	**1 - BREAKER 2**	**2 - THREE PHASE PU**
…		**3 - BF GROUND PICKUP**
		4 - 1 POLE BF DELAY
		5 - 3 POLE BF DELAY
		6 - 3POLE NOOC BF DLY
		7 - 1 POLE RETRIP DELAY
		8 - 3 POLE RETRIP DELAY
		9 - 3POLE RETRP NOOC DLY
		10 - ARC DET ENABLE
		11 - ARC DETEC PICK UP
		12 - ARC DETECTOR TIME

3.7.6 Digital Inputs and Events of the Breaker Failure Module

Table 3.7-1: Digital Inputs and Events of the Breaker Failure Module

Name	Description	Function
ENBL_BF	Breaker Failure element enable input (6IRV-A)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_BF1	Breaker Failure 1 element enable input (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_BF2	Breaker Failure 2 element enable input (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
IN_EXT_A	A pole external trip input	Activation of this input indicates the existence of a trip of A pole of the breaker generated by an external protection.
IN_EXT_B	B pole external trip input	Activation of this input indicates the existence of a trip of B pole of the breaker generated by an external protection.
IN_EXT_C	C pole external trip input	Activation of this input indicates the existence of a trip of C pole of the breaker generated by an external protection.
IN_EXT_3PH	Three-phase external trip input	Activation of this input indicates the existence of a three-phase trip of the breaker generated by an external protection.
IN_EXT	External trip input	Activation of this input indicates the existence of a trip of the breaker generated by an external protection.
IN_MEM_BF	Memorized Breaker Failure reset input (6IRV-A)	Activation of this input resets the memorized output of the breaker failure.

Table 3.7-1: Digital Inputs and Events of the Breaker Failure Module

Name	Name	Name
IN_MEM_BF1	Memorized Breaker Failure 1 reset input (6IRV-B)	Activation of this input resets the memorized output of the breaker failure 1.
IN_MEM_BF2	Memorized Breaker Failure 2 reset input (6IRV-B)	Activation of this input resets the memorized output of the breaker failure 2.
IN_BF_ST_52b	Contact position Breaker Failure start input (6IRV-A)	Activation of this input produces the start of the breaker failure without overcurrent, whenever there is a breaker pole closed.
IN_BF1_ST_52b	Contact position Breaker Failure 1 start input (6IRV-B)	Activation of this input produces the start of the breaker failure 1 without overcurrent, whenever there is a breaker pole closed.
IN_BF2_ST_52b	Contact position Breaker Failure 2 start input (6IRV-B)	Activation of this input produces the start of the breaker failure 2 without overcurrent, whenever there is a breaker pole closed.
IN_BF_ST_N	Ground unit Breaker Failure start input (6IRV-A)	Activation of this input produces the start of the breaker failure without overcurrent, provided that the neutral current detection unit is picked up.
IN_BF1_ST_N	Ground unit Breaker Failure 1 start input (6IRV-B)	Activation of this input produces the start of the breaker failure 1 without overcurrent, provided that the neutral current detection unit is picked up.
IN_BF2_ST_N	Ground unit Breaker Failure 2 start input (6IRV-B)	Activation of this input produces the start of the breaker failure 2 without overcurrent, provided that the neutral current detection unit is picked up.
ENBL_ARC	Internal arc detector enable input (6IRV-A)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_ARC1	Internal arc 1 detector enable input (6IRV-B)	
ENBL_ARC2	Internal arc 2 detector enable input 2 (6IRV-B)	

3.7.7 Digital Outputs and Events of the Breaker Failure Module

Table 3.7-2: Digital Outputs and Events of the Breaker Failure Module

Name	Description	Function
PU_BF_A1	A phase single-phase B.F. unit pick up (6IRV-A)	Pick up of the current metering unit for single-phase breaker failure detection in the corresponding phase.
PU_BF_B1	B phase single-phase B.F. unit pick up (6IRV-A)	
PU_BF_C1	C phase single-phase B.F. unit pick up (6IRV-A)	
PU_BF1_A1	A phase single-phase B.F. unit 1 pick up (6IRV-B)	Pick up of the current metering unit for single-phase breaker failure 1 detection in the corresponding phase.
PU_BF1_B1	B phase single-phase B.F. unit 1 pick up (6IRV-B)	
PU_BF1_C1	C phase single-phase B.F. unit 1 pick up (6IRV-B)	
PU_BF1_A2	A phase single-phase B.F. unit 2 pick up (6IRV-B)	Pick up of the current metering unit for single-phase breaker failure 2 detection in the corresponding phase.
PU_BF1_B2	B phase single-phase B.F. unit 2 pick up (6IRV-B)	
PU_BF1_C2	C phase single-phase B.F. unit 2 pick up (6IRV-B)	
PU_BF_A2	A phase three-phase B.F. unit pick up (6IRV-A)	Pick up of the current metering unit for three-phase breaker failure detection in the corresponding phase.
PU_BF_B2	B phase three-phase B.F. unit pick up (6IRV-A)	
PU_BF_C2	C phase three-phase B.F. unit pick up (6IRV-A)	
PU_BF1_A2	A phase three-phase B.F. unit 1 pick up (6IRV-B)	Pick up of the current metering unit for three-phase breaker failure 1 detection in the corresponding phase.
PU_BF1_B2	B phase three-phase B.F. unit 1 pick up (6IRV-B)	
PU_BF1_C2	C phase three-phase B.F. unit 1 pick up (6IRV-B)	
PU_BF2_A2	A phase three-phase B.F. unit 2 pick up (6IRV-B)	Pick up of the current metering unit for three-phase breaker failure 2 detection in the corresponding phase.
PU_BF2_B2	B phase three-phase B.F. unit 2 pick up (6IRV-B)	
PU_BF2_C2	C phase three-phase B.F. unit 2 pick up (6IRV-B)	
PU_BF_N	Ground B.F. unit pick up (6IRV-A)	Pick up of the ground current metering unit for breaker failure detection without phase overcurrent.
PU_BF1_N	Ground B.F. unit 1 pick up (6IRV-B)	Pick up of the ground current metering unit for breaker failure 1 detection without phase overcurrent.
PU_BF2_N	Ground B.F. unit 2 pick up (6IRV-B)	Pick up of the ground current metering unit for breaker failure 2 detection without phase overcurrent.

Table 3.7-2: Digital Outputs and Events of the Breaker Failure Module		
Name	**Name**	**Name**
PU_BF	Breaker Failure pick up (6IRV-A)	Pick up of the Breaker Failure.
PU_BF1	Breaker Failure 1 pick up (6IRV-B)	Pick up of the Breaker Failure 1.
PU_BF2	Breaker Failure 2 pick up (6IRV-B)	Pick up of the Breaker Failure 2.
RETRIP_A	A pole retrip (6IRV-A)	Retrip output of A pole of the breaker.
RETRIP_B	B pole retrip (6IRV-A)	Retrip output of B pole of the breaker.
RETRIP_C	C pole retrip (6IRV-A)	Retrip output of C pole of the breaker.
RETRIP_3PH	Three-phase retrip (6IRV-A)	Three-phase retrip output of the breaker.
RETRIP_A1	Breaker 1 A pole retrip (6IRV-B)	Retrip output of A pole of the breaker 1.
RETRIP_B1	Breaker 1 B pole retrip (6IRV-B)	Retrip output of B pole of the breaker 1.
RETRIP_C1	Breaker 1 C pole retrip (6IRV-B)	Retrip output of C pole of the breaker 1.
RETRIP_3PH1	Breaker 1 Three-phase retrip (6IRV-B)	Three-phase retrip output of the breaker 1.
RETRIP_A2	Breaker 2 A pole retrip (6IRV-B)	Retrip output of A pole of the breaker 2.
RETRIP_B2	Breaker 2 B pole retrip (6IRV-B)	Retrip output of B pole of the breaker 2.
RETRIP_C2	Breaker 2 C pole retrip (6IRV-B)	Retrip output of C pole of the breaker 2.
RETRIP_3PH2	Breaker 2 Three-phase retrip 2 (6IRV-B)	Three-phase retrip output of the breaker 2.
BF	Breaker Failure (6IRV-A)	Activation of Breaker Failure.
BF1	Breaker Failure 1 (6IRV-B)	Activation of Breaker Failure 1.
BF2	Breaker Failure 2 (6IRV-B)	Activation of Breaker Failure 2.
BF_MEM	Memorized Breaker Failure (6IRV-A)	Activation of memorized Breaker Failure.
BF_MEM1	Memorized Breaker Failure 1 (6IRV-B)	Activation of memorized breaker failure 1.
BF_MEM2	Memorized Breaker Failure 2 (6IRV-B)	Activation of memorized breaker failure 2.
BF_ENBLD	Breaker Failure unit enabled (6IRV-A)	Indication of enabled or disabled status of the unit.
BF_ENBLD1	Breaker Failure 1 unit enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
BF_ENBLD2	Breaker Failure 2 unit enabled (6IRV-B)	Indication of enabled or disabled status of the unit.

Table 3.7-2: Digital Outputs and Events of the Breaker Failure Module		
Name	**Name**	**Name**
ACT_DET_ARC	Arc Detector activation (6IRV-A)	Activation of the unit.
ACT_DET_ARC1	Arc Detector 1 activation (6IRV-B)	Activation of the unit.
ACT_DET_ARC2	Arc Detector 2 activation (6IRV-B)	Activation of the unit.
ARC_ENBLD	Internal arc detector unit enabled (6IRV-A)	Indication of enabled or disabled status of the unit.
ARC_ENBLD1	Internal arc detector unit 1 enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
ARC_ENBLD2	Internal arc detector unit 2 enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
ENBL_BF	Breaker failure element enable input (6IRV-A)	The same as for the Digital Inputs.
ENBL_BF1	Breaker failure element enable 1 input (6IRV-B)	The same as for the Digital Inputs.
ENBL_BF2	Breaker failure element enable 2 input (6IRV-B)	The same as for the Digital Inputs.
IN_EXT_A	A pole external trip input	The same as for the Digital Inputs.
IN_EXT_B	B pole external trip input	The same as for the Digital Inputs.
IN_EXT_C	C pole external trip input	The same as for the Digital Inputs.
IN_EXT_3PH	Three-phase external trip input	The same as for the Digital Inputs.
IN_EXT	External trip input	The same as for the Digital Inputs.
IN_MEM_BF	Memorized Breaker Failure reset input (6IRV-A)	The same as for the Digital Inputs.
IN_MEM_BF1	Memorized Breaker Failure 1 reset input (6IRV-B)	The same as for the Digital Inputs.
IN_MEM_BF2	Memorized Breaker Failure 2 reset input (6IRV-B)	The same as for the Digital Inputs.
IN_BF_ST_52b	Contact position Breaker Failure start input (6IRV-A)	The same as for the Digital Inputs.
IN_BF_ST_52b1	Contact position Breaker Failure 1 start (6IRV-B)	The same as for the Digital Inputs.
IN_BF_ST_52b2	Contact position Breaker Failure 2 start (6IRV-B)	The same as for the Digital Inputs.
IN_BF_ST_N	Ground unit Breaker Failure start input (6IRV-A)	The same as for the Digital Inputs.
IN_BF_ST_N1	Ground unit Breaker Failure 1 start input (6IRV-B)	The same as for the Digital Inputs.
IN_BF_ST_N2	Ground unit Breaker Failure 2 start input (6IRV-B)	The same as for the Digital Inputs.
ENBL_ARC	Internal arc detector enable input (6IRV-A)	The same as for the Digital Inputs.
ENBL_ARC1	Internal arc detector 1 enable input (6IRV-B)	The same as for the Digital Inputs.
ENBL_ARC2	Internal arc detector 2 enable input (6IRV-B)	The same as for the Digital Inputs.

3.7.8 Breaker Failure Unit Test

To verify the activation of the breaker failure element the **Information** - **Status** - **Measuring Elements** - **Breaker Failure** menu or in the ***ZIVercomPlus***® to **Status** - **Elements** - **Breaker Failure** should be accessed and the statuses of the Breaker Failure and Memorized Breaker Failure flags should be contrasted.

To carry out the tests, in addition to the breaker failure element itself, the distance elements should be enabled (the remaining disabled elements).

The pick up levels of the breaker failure elements should be adjusted (single-phase, three-phase and ground pick up) at 0.5 A. Similarly, the single-phase, three-phase and three-phase without load breaker failure times should be adjusted to 0.5 s.

3.7.8.a Single-Phase Breaker Failure

Apply a current of 1 A to phase A. Activate the **IN_EXT_A** (**A Phase External Protection Actuation**) input and verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the current and verify that, although the breaker failure signal resets, the memorized breaker failure output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

3.7.8.b Three-Phase Breaker Failure

Apply a fault such that the trip does not disconnect the currents (with these being higher than 0.5 A). Verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the currents and verify that although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

Apply a current of 1 A to A and B phases. Activate the **IN_EXT_3PH** (**External Three-Phase Trip**) input or the **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C** inputs simultaneously (**A Phase**, **B Phase** and **C Phase External Protection Actuation**) and verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the current and verify that, although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

3.7.8.c Three-Phase Breaker Failure without Load

Activate the **IN_BF_ST_52b** (**Contact Position Breaker Failure Start** input) input without activating the **IN_3POL_AND** (**Three Open Pole**) input or the **IN_52bA**, **IN_52bB**, **IN_52bC** inputs (simultaneously). Verify that **Breaker Failure** and **Memorized Breaker Failure** flags are activated at 0.5 s.

Deactivate the **IN_BF_ST_52b** input and verify that, although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

Apply a current of 3 A to phase C and activate the **IN_BF_ST_N** (**Ground Element Breaker Failure Start**) input. Verify that **Breaker Failure** and **Memorized Breaker Failure** flags are activated at 0.5 s.

Disconnect the current and verify that, although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

3.7.8.d Internal Arc Detector

Since this is considered a complement to the Breaker Failure element, the tests of this element are included in the same section

Consult the following indicators during the test: In the display on the **Information** - **Status** - **Measuring Elements** - **Breaker Failure** - **Internal Arc** menu, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Breaker Failure** - **Internal Arc**).

Disable the Breaker Failure element and enable that of Internal Arc detection. Adjust the pick up to 0.1 A and the timing to 0.5 s. Apply a current of 0.5 A to phase B and activate the **IN_52bB** input. Verify that the **Internal Arc Detector** flag is activated at 0.5 s.

Note: 6IRV-B relay phase currents used for testing breaker 1 failure element will be IA-1, IB-1 and IC-1 and IA-2, IB-2, IC-2 for breaker 2 failure element.

3.8 Open Pole Detector

3.8.1 Operating Principles

This unit detects the opening of any pole of the breaker, generating the corresponding outputs (**A Pole Open**, **B Pole Open** and **C Pole Open**), based not only on the condition of the breaker position contacts but also on the output of the three undercurrent detectors, one for each pole, whose levels are given by the following adjustments: **A Pole Open Current Level**, **B Pole Open Current Level** and **C Pole Open Current Level.** With the aperture indication outputs of each pole, the open pole detector also generates the following outputs: **One Open Pole**, **Three Open Poles** or **Any Open Pole**.

The outputs of this unit are used by other units which carry out modifications in the operating logic to adapt to the new situation which causes the opening of any pole of the breaker.

The Open Pole Detector can operate based on two operating logics, exclusive within themselves, each of which can be selected through the **Number of Inputs for Breaker Position** setting. If this setting takes the value **3 Inputs**, the operating logic will be the following:

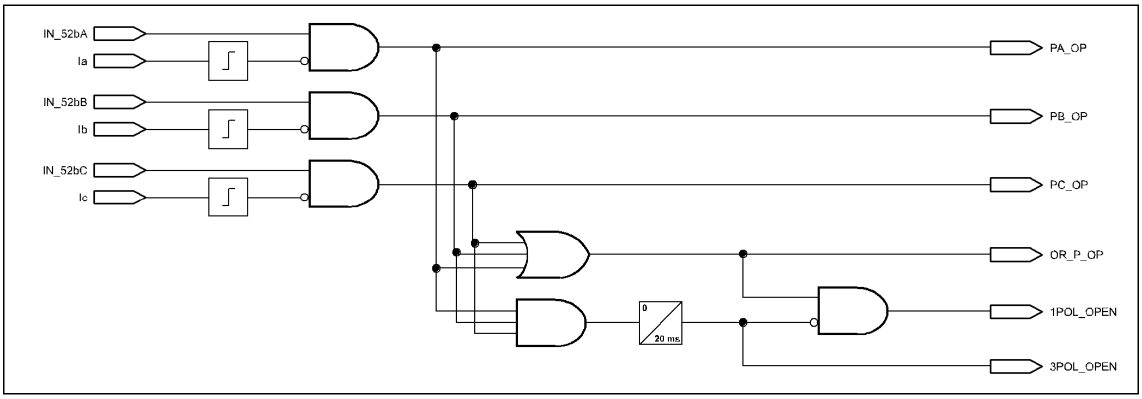


Figure 3.8.1: Logic Diagram of the Open Pole Detector for 6IRV-A Relays (I).

IN_52bA, **IN_52bB** e **IN_52bC** inputs are designed to receive breaker **52b** normally closed contact state. However, using programmable logic, said logic inputs could receive breaker 52a contact (use operator NOT) or both **52b** and **52a** contacts (use operators NOT and AND) state.

The reset time of 20 ms associated with the **Three Pole Open** (**3POL_OPEN**) signal will be used to avoid transient activation of the **One Pole Open** (**1POL_OPEN**) signal in case of imbalances which arise in a three-phase reclose.

If the **Number of Inputs for Breaker Position** setting takes the value **2 Inputs**, the operating logic used becomes the following:

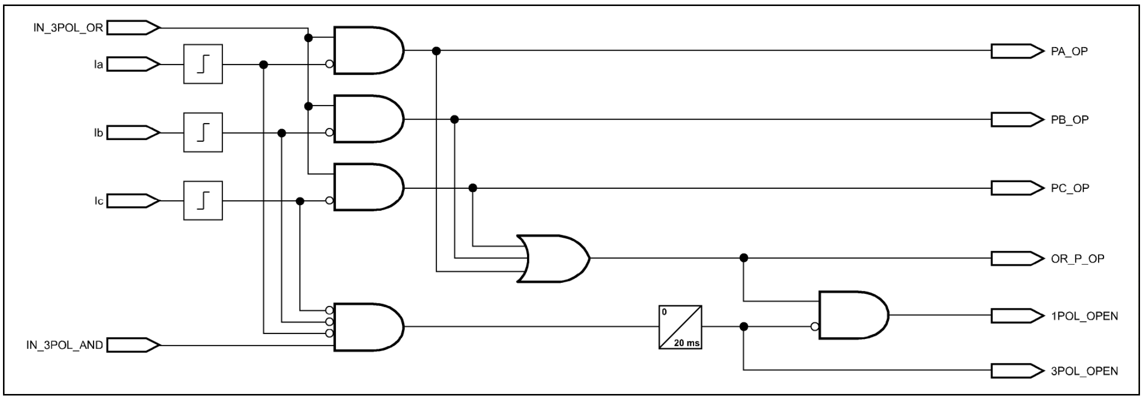


Figure 3.8.2: Logic Diagram of the Open Pole Detector for 6IRV-A Relays (II).

This logic allows using one less input than the logic above. Inputs **IN_3POL_OR** and **IN_3POL_AND** are designed to receive one **OR** and one **AND,** respectively, from the breaker **52b** normally closed contacts. However, using programmable logic, one OR and one AND from the **52 a** normally open contacts or both **52b** and **52a** contacts can also be assigned.

The reset time of 20 ms associated with the **Three Pole Open** (**3POL_OPEN**) signal is used, as in the previous logic, to avoid transient activation of the **One Pole Open** (**1POL_OPEN**) signal in case of imbalances which occur in a three-phase reclose.

The outputs of the Open Pole Detector are used by the following units or logics: Phase Selector, Ground and Negative Sequence Overcurrent Units, Fuse Failure Detector and Recloser.

3.8.2 Open Pole Detector in 6IRV-B Relays

6IRV-B relay open pole detector allows supervising two breakers (applicable to breaker-and-a-half, ring or two bus and dual breaker configurations) when **Supervised Breakers** setting is set to **Breaker 1+Breaker 2**. Option **Breaker 1** must be selected in single breaker bays or when in a dual breaker bay, the breaker selected as “Breaker 2” is out of operation. Similarly, option **Breaker 2** must be selected in dual breaker bays when the breaker selected as “Breaker 1” is out of operation. When the **Supervised Breakers** setting is set to **ED Selection**, the breaker or breakers to be supervised will be determined by the relay through the logic inputs **IN_SUP1 (Breaker 1 Open Pole Supervision Input)** and **IN_SUP2 (Breaker 2 Open Pole Supervision Input)** based on the following table:

IN_SUP1	IN_SUP2	Result
0	0	Breaker 1 (default value): activation of **Breaker 1 Open Pole Supervision** output
0	1	Breaker 2: activation of **Breaker 2 Open Pole Supervision** output
1	0	Breaker 1: activation of **Breaker 1 Open Pole Supervision** output
1	1	Breaker 1+Breaker 2: activation of **Breaker 1 and Breaker 2 Open Pole Supervision** output

If **Nº of Breaker State Inputs** setting takes the value **3 Inputs** the operating logic will be as follows:

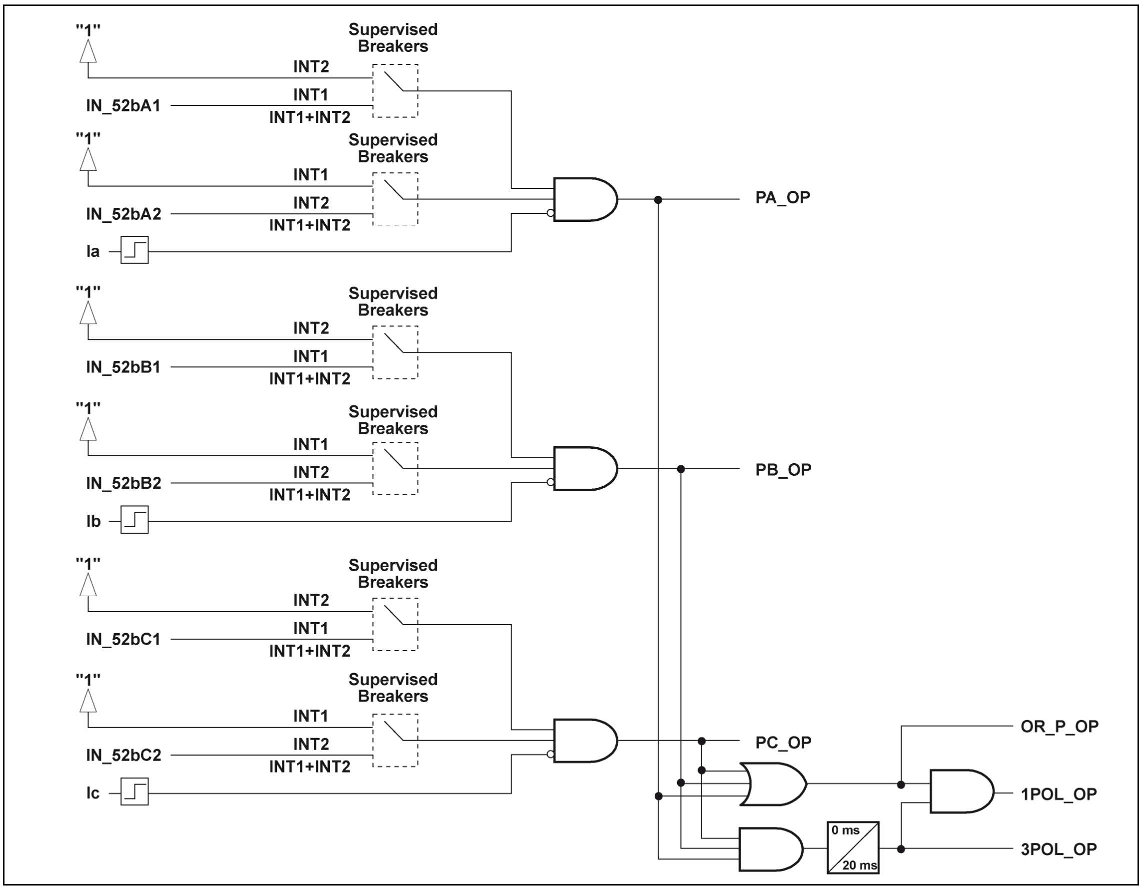


Figure 3.8.3: Logic Diagram of Open Pole Detector for a 6IRV-B Relay (I).

If **Nº of Breaker State Inputs** setting takes the value **2 Inputs** the operating logic will be as follows:

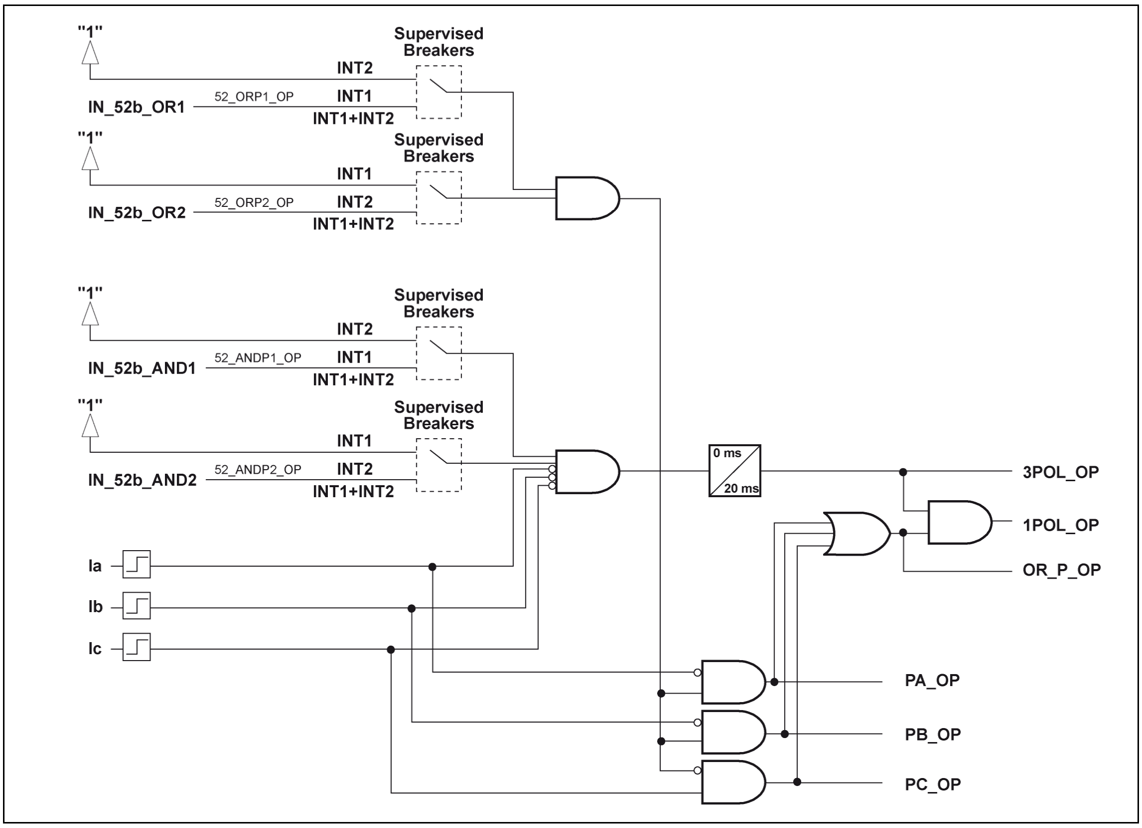


Figure 3.8.4: Logic Diagram of Open Pole Detector for a 6IRV-B Relay (II).

3.8.3 Open Pole Detector Settings

Open Pole Detector			
Setting	**Range**	**Step**	**By default**
Number of Inputs for Breaker Position	3 / 2		3
Supervised Breakers (6IRV-B)	Breaker 1 Breaker 2 Breaker 1 + Breaker 2 Selection by DI		Breaker 1
Phase A Current Level	(0.04 - 0.8) In A	0.01 A	0.04 In
Phase B Current Level	(0.04 - 0.8) In A	0.01 A	0.04 In
Phase C Current Level	(0.04 - 0.8) In A	0.01 A	0.04 In

- **Open Pole Detector: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**2 - OPEN POLE LOGIC**
3 - INFORMATION	….	…

0 - FUSE FAILURE	**0 - OPEN POLE SELECTION**
…	**1 - A POLE OPEN CURRENT**
2 - OPEN POLE LOGIC	**2 - B POLE OPEN CURRENT**
…	**3 - C POLE OPEN CURRENT**

6IRV-B MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**2 - OPEN POLE LOGIC**
3 - INFORMATION	….	…

0 - FUSE FAILURE	**0 - OPEN POLE SELECTION**
…	**1 - BRKS TO SUPERVISE**
2 - OPEN POLE LOGIC	**1 - A POLE OPEN CURRENT**
…	**2 - B POLE OPEN CURRENT**
	3 - C POLE OPEN CURRENT

3.8.4 Digital Inputs and Events of the Open Pole Detector

Tabla 3.8-1: Digital Inputs and Events of the Open Pole Detector

Name	Description	Function
IN_52bA	Open A pole position input (6IRV-A)	Activation of this input indicates that 52b contact of A pole position of the breaker is closed.
IN_52bB	Open B pole position input (6IRV-A)	Activation of this input indicates that 52b contact of B pole position of the breaker is closed.
IN_52bC	Open C pole position input (6IRV-A)	Activation of this input indicates that 52b contact of C pole position of the breaker is closed.
IN_3POL_AND	Open three pole input (6IRV-A)	The activation of this input indicates that the three 52b contacts of the pole position of the breaker are closed.
IN_3POL_OR	Any pole open input (6IRV-A)	The activation of this input indicates that any 52b contact of the pole position of the breaker is closed.

Table 3.8-1: Digital Inputs and Events of the Open Pole Detector		
Name	**Description**	**Function**
IN_52bA1	Breaker 1 A pole open state input (6IRV-B)	Its activation indicates that breaker 1 A pole 52b contact state is closed.
IN_52bB1	Breaker 1 B pole open state input (6IRV-B)	Its activation indicates that breaker 1 B pole 52b contact state is closed.
IN_52bC1	Breaker 1 C pole open state input (6IRV-B)	Its activation indicates that breaker 1 C pole 52b contact state is closed.
IN_52bA2	Breaker 2 A pole open state input (6IRV-B)	Its activation indicates that breaker 2 A pole 52b contact state is closed.
IN_52bB2	Breaker 2 B pole open state input (6IRV-B)	Its activation indicates that breaker 2 B pole 52b contact state is closed.
IN_52bC2	Breaker 2 C pole open state input (6IRV-B)	Its activation indicates that breaker 2 C pole 52b contact state is closed.
IN_52b_AND1	Breaker 1 three pole open state input (6IRV-B)	Its activation indicates that the breaker 1 three pole 52b contacts state is closed.
IN_52b_OR1	Any breaker 1 pole open state input (6IRV-B)	Its activation indicates that breaker 1 any pole 52b contact state is closed.
IN_52b_AND2	Any breaker 2 pole open state input (6IRV-B)	Its activation indicates that the breaker 2 three pole 52b contacts state is closed.
IN_52b_OR2	Any breaker 2 pole open state input (6IRV-B)	Its activation indicates that breaker 2 any pole 52b contact state is closed.
IN_SUP1	Breaker 1 open pole supervision input (6IRV-B)	Its activation indicates that breaker 1 is to be supervised (it is taken into account only if Supervised Breakers setting is set to ED Selection).
IN_SUP2	Breaker 2 open pole supervision input (6IRV-B)	Its activation indicates that breaker 2 is to be supervised (it is taken into account only if Supervised Breakers setting is set to ED Selection).

3.8.5 Digital Outputs and Events of the Open Pole Detector

Tabla 3.8-2: Digital Outputs and Events of the Open Pole Detector

Name	Description	Function
PA_OP	Open A pole	Open A pole indication
PB_OP	Open B pole	Open B pole indication
PC_OP	Open C pole	Open C pole indication
OR_P_OP	Any pole open	Any pole open indication.
1POL_OPEN	One pole open	One pole open indication. It is also activated when 2 poles open.
3POL_OPEN	Three poles open	Three poles open indication.
IN_52bA	Open A pole position input (6IRV-A)	The same as for the digital inputs.
IN_52bB	Open B pole position input (6IRV-A)	
IN_52bC	Open C pole position input (6IRV-A)	
IN_3POL_AND	Open three pole input (6IRV-A)	The same as for the digital inputs.
IN_3POL_OR	Any pole open input (6IRV-A)	The same as for the digital inputs.
IN_52bA1	Breaker 1 A pole open state input (6IRV-B relay)	The same as for the digital inputs.
IN_52bB1	Breaker 1 B pole open state input (6IRV-B relay)	The same as for the digital inputs.
IN_52bC1	Breaker 1 C pole open state input (6IRV-B relay)	The same as for the digital inputs.
IN_52bA2	Breaker 2 A pole open state input (6IRV-B relay)	The same as for the digital inputs.
IN_52bB2	Breaker 2 B pole open state input (6IRV-B relay)	The same as for the digital inputs.
IN_52bC2	Breaker 2 C pole open state input (6IRV-B relay)	The same as for the digital inputs.
IN_52b_AND1	Breaker 1 three poles open input (6IRV-B)	The same as for the digital inputs.
IN_52b_OR1	Breaker 1 any pole open input (6IRV-B)	The same as for the digital inputs.
IN_52b_AND2	Breaker 2 three poles open input (6IRV-B)	The same as for the digital inputs.
IN_52b_OR2	Breaker 2 any pole open input (6IRV-B)	The same as for the digital inputs.
IN_SUP1	Breaker 1 open pole supervision input (6IRV-B)	The same as for the digital inputs.
IN_SUP2	Breaker 2 open pole supervision input (6IRV-B)	The same as for the digital inputs.

Table 3.8-2: Digital Outputs and Events of the Open Pole Detector		
Name	**Description**	**Function**
52_ORP1_OP	Any breaker 1 pole open by contact indication (6IRV-B)	Indication of any breaker 1 pole open based only on said breaker state contacts.
52_ORP2_OP	Any breaker 2 pole open by contact indication (6IRV-B)	Indication of any breaker 2 pole open based only on said breaker state contacts.
52_ANDP1_OP	Three breaker 1 poles open by contact indication (6IRV-B)	Indication of three breaker 1 poles open based only on said breaker state contacts.
52_ANDP2_OP	Three breaker 2 poles open by contact indication (6IRV-B)	Indication of three breaker 2 poles open based only on said breaker state contacts.
SUP1	Breaker 1 open pole supervision (6IRV-B)	Its activation indicates that only the breaker 1 is being supervised
SUP2	Breaker 2 open pole supervision (6IRV-B)	Its activation indicates that only the breaker 2 is being supervised.

3.9 Pole Discordance Detector

3.9.1 Introduction

This unit is for the purpose of detecting a discordance in the position of the three breaker poles. If this condition is maintained during the **T_PD** (**Discordance Time**) time setting, the **TRIP_PD** (**Pole Discordance Detector Trip**) trip signal is generated. Given that the single-phase reclose cycles will produce a pole discordance condition, the **T_PD** time setting should be longer than the single-phase reclose time.

Figure 3.9.1 shows the operation diagram of the Pole Discordance Detector.

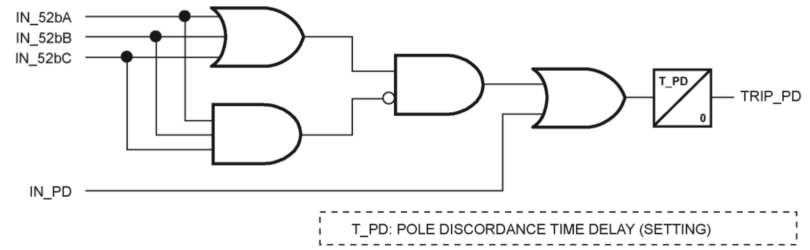


Figure 3.9.1: Diagram of the Pole Discordance Detector.

It will be possible to detect the existence of pole discordance from the status of the three digital inputs associated with the status of the three poles of the breaker (activated if the corresponding pole is open). Notwithstanding, many breakers incorporate a wiring logic in their control cabinets, which detects the pole discordance (based on the status of the **52aA/B/C** and **52bA/B/C** contacts), generating a signal in this case. For this reason, the **6IRV** IED incorporates a digital input, **IN_PD**, to receive this signal, which will directly activate the **TRIP_PD** output.

3.9.2 6IRV-B Relay Pole Discordance

For applications in breaker and a half and ring substations, **6IRV-B** relays incorporate two pole discordance elements, designated element 1 and element 2, respectively, to supervise the breakers 1 and 2, respectively.

Each element discerns a discordance situation on one pole open, two poles open or any pole open, including separate timers for each situation. The pole discordance logic n (n = 1, 2) is shown below.

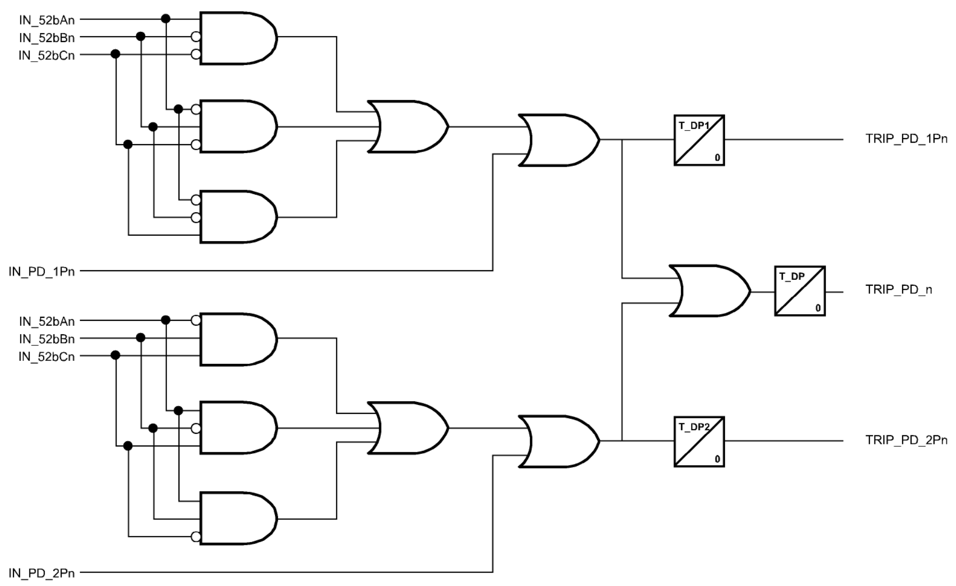


Figure 3.9.2: 6IRV-B Relay Pole Discordance Detector Diagram.

The single/three phase trip logic (see paragraph 3.17) uses the **TRIP_PDn** (**Breaker n any Pole Open Discordance Trip**) signal; however, **6IRV-B** relay logic is provided with a programmable trip input, which can be assigned through the programmable logic to any of the signals **TRIP_PD_1Pn** (**Breaker n Single Pole Open Discordance Trip**) or **TRIP_PD_2Pn** (**Breaker n Two Poles Open Discordance Trip**) in order to produce, based on them, a three-phase trip.

3.9.3 Pole Discordance Detector Settings

Pole Discordance Detector			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Poles Discordance Time delay (6IRV-A)	0 - 50 s	0.01 s	2 s
Single Pole Open Discordance Time delay (6IRV-B)	0 - 50 s	0.01 s	2 s
Two Pole Open Discordance Time delay (6IRV-B)	0 - 50 s	0.01 s	2 s
Any Pole Open Discordance Time delay (6IRV-B)	0 - 50 s	0.01 s	2 s

- **Pole Discordance Detector: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**12 - POLE DISCREPANCY**
3 - INFORMATION	….	…

0 - FUSE FAILURE	**0 - POLE DISCR ENABLE**
…	**1 - POLE DISCREP. DELAY**
12 - POLE DISCREPANCY	
…	

6IRV-B MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**13 - POLE DISCREPANCY**
3 - INFORMATION	…	…

0 - FUSE FAILURE	**0 - BREAKER 1**	**0 - POLE DISCR ENABLE**
…	**1 - BREAKER 2**	**1 - TIME 1 POLE OPEN**
13 - POLE DISCREPANCY		**2 - TIME 2 POLE OPEN**
…		**3 - TIME ANY POLE OPEN**

3.9.4 Digital Inputs and Events of the Pole Discordance Detector

Table 3.9-1: Digital Inputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
ENBL_PD	Pole discordance detector enable input (6IRV-A)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_PD1	Pole discordance detector enable input breaker 1 (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_PD2	Pole discordance detector enable input breaker 2 (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
IN_52bA	Open A pole position input (6IRV-A)	Activation of this input indicates that the 52b contact of A pole position of the breaker is closed.
IN_52bB	Open B pole position input (6IRV-A)	Activation of this input indicates that the 52b contact of B pole position of the breaker is closed.
IN_52bC	Open C pole position input (6IRV-A)	Activation of this input indicates that the 52b contact of C pole position of the breaker is closed.
IN_52bA1	Open A pole position input breaker 1 (6IRV-B)	Activation of this input indicates that the 52b contact of A pole position of the breaker 1 is closed.
IN_52bB1	Open B pole position input breaker 1 (6IRV-B)	Activation of this input indicates that the 52b contact of B pole position of the breaker 1 is closed.
IN_52bC1	Open C pole position input breaker 1 (6IRV-B)	Activation of this input indicates that the 52b contact of C pole position of the breaker 1 is closed.

Table 3.9-1: Digital Inputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
IN_52bA2	Open A pole position input breaker 2 (6IRV-B)	Activation of this input indicates that the 52b contact of A pole position of the breaker 2 is closed.
IN_52bB2	Open B pole position input breaker 2 (6IRV-B)	Activation of this input indicates that the 52b contact of B pole position of the breaker 2 is closed.
IN_52bC2	Open C pole position input breaker 2 (6IRV-B)	Activation of this input indicates that the 52b contact of C pole position of the breaker 2 is closed.
IN_PD	Pole discordance detector input (6IRV-A)	Activation of this input directly generates the startup of the timer associated with the pole discordance detector.
IN_PD_1P1	Single open pole discordance detector input breaker 1 (6IRV-B)	Activation of this input directly generates the startup of the timer associated with the breaker 1 single open pole discordance detector.
IN_PD_1P2	Single open pole discordance detector input breaker 2 (6IRV-B)	Activation of this input directly generates the startup of the timer associated with the breaker 2 single open pole discordance detector.
IN_PD_2P1	Two open poles discordance detector input breaker 1 (6IRV-B)	Activation of this input directly generates the startup of the timer associated with the breaker 1 two open poles discordance detector.
IN_PD_2P2	Two open poles discordance detector input breaker 2 (6IRV-B)	Activation of this input directly generates the startup of the timer associated with the breaker 2 two open poles discordance detector.

3.9.5 Digital Outputs and Events of the Pole Discordance Detector

Table 3.9-2: Digital Outputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
TRIP_PD	Pole discordance detector trip (6IRV-A)	Trip of the unit.
TRIP_PD1	Pole discordance detector trip breaker 1 (6IRV-B)	Trip of the unit.
TRIP_PD2	Pole discordance detector trip breaker 2 (6IRV-B)	Trip of the unit.
TRIP_PD_1P1	Single pole open discordance detector trip breaker 1 (6IRV-B)	Trip of the unit by a single pole open.
TRIP_PD_1P2	Single pole open discordance detector trip breaker 2 (6IRV-B)	Trip of the unit by a single pole open.
TRIP_PD_2P1	Single pole open discordance detector trip breaker 1 (6IRV-B)	Trip of the unit by two poles open.
TRIP_PD_2P2	Single pole open discordance detector trip breaker 2 (6IRV-B)	Trip of the unit by two poles open.
PD_ENBLD	Pole discordance detector enabled (6IRV-A)	Indication of enabled or disabled status of the unit.
PD1_ENBLD	Pole discordance detector enabled breaker 1 (6IRV-B)	Indication of enabled or disabled status of the unit.
PD2_ENBLD	Pole discordance detector enabled breaker 2 (6IRV-B)	Indication of enabled or disabled status of the unit.
ENBL_PD	Pole discordance detector enable input (6IRV-A)	The same as for the Digital Input.
ENBL_PD1	Pole discordance detector enable input breaker 1 (6IRV-B)	The same as for the Digital Input.
ENBL_PD2	Pole discordance detector enable input breaker 2 (6IRV-B)	The same as for the Digital Input.
IN_52bA	Open A pole position input (6IRV-A)	The same as for the Digital Input.
IN_52bB	Open B pole position input (6IRV-A)	The same as for the Digital Input.
IN_52bC	Open C pole position input (6IRV-A)	The same as for the Digital Input.
IN_52bA1	Open A pole position input breaker 1 (6IRV-B)	The same as for the Digital Input.
IN_52bB1	Open B pole position input breaker 1 (6IRV-B)	The same as for the Digital Input.
IN_52bC1	Open C pole position input breaker 1 (6IRV-B)	The same as for the Digital Input.
IN_52Ba2	Open A pole position input breaker 2 (6IRV-B)	The same as for the Digital Input.
IN_52bB2	Open B pole position input breaker 2 (6IRV-B)	The same as for the Digital Input.
IN_52bC2	Open C pole position input breaker 2 (6IRV-B)	The same as for the Digital Input.

Table 3.9-2: Digital Outputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
IN_PD	Pole discordance detector input (6IRV-A)	The same as for the Digital Input.
IN_PD_1P1	Single open pole discordance detector input breaker 1 (6IRV-A)	The same as for the Digital Input.
IN_PD_1P2	Single open pole discordance detector input breaker 2 (6IRV-B)	The same as for the Digital Input.
IN_PD_2P1	Two open poles discordance detector input breaker 1 (6IRV-B)	The same as for the Digital Input.
IN_PD_2P2	Two open poles discordance detector input breaker 2 (6IRV-B)	The same as for the Digital Input.

3.9.6 Pole Discordance Detector Test

The following indicators will be monitored during the test:

In the display on the **Information** - **Status** - **Measuring elements** - **Pole Discordance** screen, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Pole Discordance**).

- **6IRV-A Models**

The pole discordance element will be enabled and the remaining elements disabled.

Adjust the timing to 10 s.

Activate the **Open A Pole Position** input, without the **Open B Pole Position** and **Open C Pole Position** inputs being active. Verify that a three-phase trip due to pole discordance is produced after 10 s.

Repeat the test with the **Open A Pole Position** and **Open B Pole Position** inputs active without the **Open C Pole Position** input active. Verify that a three-phase trip due to pole discordance is produced after 10 s.

Activate the **Pole Discordance** input and verify that a three-phase trip due to pole discordance is produced after 10 s.

- **6IRV-B Models**

6IRV-B relays incorporate two pole discordance elements. Below are described the tests to be carried out on element 1:

Single Pole Open Discordance Test

Activate the **Breaker 1 Open A Pole Position** input. Check that **Breaker 1 Single Pole Open Discordance Trip** and **Breaker 1 Pole Discordance Trip** signals activate after the proper time delays.

Check the activation of the above signals after the proper time delay when **Breaker 1 Open B Pole Position** and **Breaker 1 Open C Pole Position** inputs are activated separately**.**

Activate **Breaker 1 Single Pole Open Discordance** input**.** Check the above signals activate after the proper time delay.

Two Pole Open Discordance Test

Activate the **Breaker 1 Open A Pole Position** and **Breaker 1 Open B Pole Position** inputs**.** Check that **Breaker 1 Two Pole Open Discordance Trip** and **Breaker 1 Pole Discordance Trip** signals activate after the proper time delays.

Activate **Breaker 1 Open B Pole Position** and **Breaker 1 Open C Pole Position** inputs**.** Check the above signals activate after the proper time delay.

Activate **Breaker 1 Open C Pole Position** and **Breaker 1 Open A Pole Position** inputs**.** Check the above signals activate after the proper time delay.

Activate **Breaker 1 Two Pole Open Discordance** input. Check the above signals activate after the proper time delay.

3.10 Synchronism Unit

3.10.1 Description

6IRV relays incorporate one or two synchronism check elements (depending on model) the function of which is to check whether the conditions at both ends of the supervised breaker are suitable to closing it (either by reclose or manual reset) and that there will be no oscillations.

The functioning of the synchronism unit is based, on one hand, on comparing the module, phase and/or frequency of the voltages on **Side A** (**Line**) and **Side B** (**Busbar**) to check if the two voltages are the same. On the other hand, the element can detect synchronism according to the energization on both sides of the breaker, that is, in terms of the possible combinations of presence/absence of voltage on sides A and B.

6IRV-A relays include one single synchronism element that uses the voltage measure by channel VSYNC as **Side B** voltage. However, in order to supervise the synchronism of the two breakers associated to a breaker and a half or ring bay, **6IRV-B** relays incorporate two synchronism elements to supervise breakers 1 and 2, designated element 1 and element 2 respectively, which will use the voltages measured by channels VSYNC1 and VSYNC2, respectively, as **side B** voltage.

However, if the setting **ED Supervision for VSINC Selection** is set to **Yes**, the voltages used by the synchronisation elements will depend on the inputs **IN_89B1_OP** (**Busbar Sectionalizing Switch 1 Open**) and **IN_89B2_OP** (**Busbar Sectionalizing Switch 2 Open**), according to Tables 3.10-1 (dual busbar bays) and 3.10-2 (Breaker and a half bays).

- **Dual busbar (Line Current I1 or I2)**

Table 3.10-1: Voltage Channel used by the Synchronization Elements 1 in a Dual Busbar Configuration (Line Current I1 or I2)

E_89B1_A	E_89B2_A	Result
0	0	VSINC1
0	1	VSINC1
1	0	VSINC2
1	1	VSINC1

The synchronism element 1 must be used, namely, recloser 1.

- **Breaker and a Half (Line Current I1+I2)**

The synchronism element 1 uses VSINC1.

Table 3.10-2: Voltage Channel used by the Synchronization Element 2 in a Breaker and a Half Configuration

E_89B2_A	Result
0	VSINC1
1	VSINC1

The voltage on **Side B** may correspond to phase A, B or C or phase-to-phase AB, BC or CA voltage as a function of the situation of the transformer on the busbar side. In order to compare said voltage with that of **Side A**, the **Side B** voltage setting must be adequately configured. This setting will be used for angle compensation so that voltage on **Side B** may be compensated, as far as angle is concerned, through voltage on **Side A**.

In case phase-to-phase voltage is used on **Side B** for synchronism check, model compensation is required besides angle compensation, in order to compare voltages on both sides. To this end, **Side B Voltage Compensation Factor** (**K_{LB}**) setting must be set properly. As for magnitudes, the measured values are standardized, considering line-to-neutral voltages on both sides. As for angles, they are compensated according to the values shown in Table 3.10-1. Magnitude standardization and angle compensation is made through the following settings:

- **Voltage on Side B**: through this setting, the measured value of the voltage on **side B** of the breaker is selected and the angle compensation to be used established. This setting is not considered for magnitude standardization.
- **Side B Voltage Compensation Factor B** (**K_{LB}**): based on the rated voltage on **side A**, the rated voltage on **side B** is compensated through multiplication by parameter **K_{LB}** for standardization so that voltage difference criterion may be used for synchronism. Parameter **K_{LB}** is calculated as:

$$K_{LB} = \frac{V_{nominal SIDE\_A}}{V_{nominal SIDE\_B}}$$

The synchronism unit also takes into account the system's phase sequence (ABC or ACB). Appropriate angle compensation depends on **Phase Sequence** (ABC / ACB) setting.

For example, if the voltage of side A is **A Phase** voltage and the voltage of side B is **B Phase** voltage, angle compensation for ABC sequence systems will be 120º; if system sequence is ACB, compensation will be 240º. Table 3.10-3 lists all angle compensation possibilities:

Table 3.10-3: Angle Compensation (Phase Sequence)

Side A	Side B voltage setting	ABC Sequence	ACB Sequence
V_A	V_A	0º	0º
V_A	V_B	120º	240º
V_A	V_C	240º	120º
V_A	V_{AB}	330º	30º
V_A	V_{BC}	90º	270º
V_A	V_{CA}	210º	150º

All angles measured with respect to V_A.

See the block diagram of the synchronism unit in figure 3.10.1.

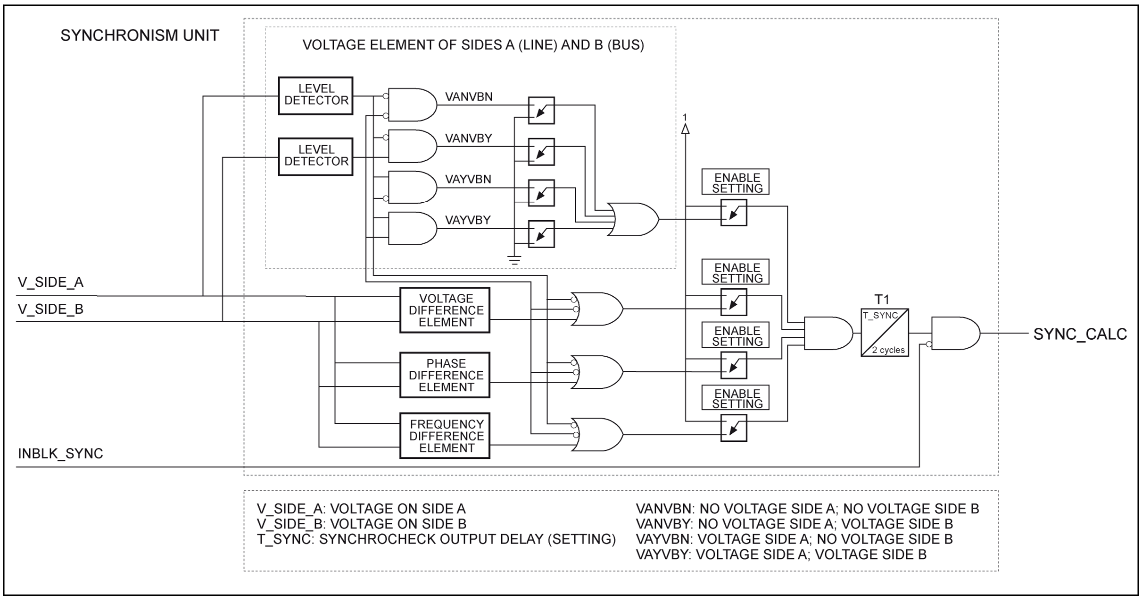


Figure 3.10.1:Block Diagram of the Synchronism Unit.

Note: the diagram shows that, if a permission value is 0 (element disabled), the input of the AND gate corresponding to this element will be at 1 as if this element were picked up. Therefore, if all the elements are disabled, the synchronism unit will be activated (unless it is blocked externally).

Note: the diagram shows that, if the bay overvoltage element and/or the bus overvoltage element are reset, the inputs to the AND gate corresponding to the voltage difference, angle difference and frequency difference elements are always at 1.

The Synchronism Unit output (**SYNC_CALC**) can be blocked with the **Block Synchronism Check** (**INBLK_SYNC**) digital input.

The Synchronism Unit is comprised of four elements (voltage elements of sides A and B, voltage, phase and frequency difference elements). Each has a permission (**Enable**) setting. Details of its operation are explained next.

3.10.2 Voltage Difference Element

This element picks up when the voltage difference between the signals of sides A and B is less than or equal to the set value (in percentage), and resets when the ratio between the voltages of sides A and B is equal to or greater than 105% of the set value.

$$\text{(Startup value)} \left| \frac{\text{V sideA}}{\text{V sideB}} - 1 \right| \leq \text{setting}$$

$$\text{(Reset value)} \left| \frac{\text{V line}}{\text{V bus}} - 1 \right| \geq \text{setting} \times 1{,}05$$

3.10.3 Phase Difference Element

This element picks up when the phase displacement between the signals of sides A and B is less than or equal to the setting and resets when the phase displacement angle is greater than 105% of the set value or greater than the set value +2º.

If the **Breaker Closing Time Compensation** is set to **YES**, the phase difference element will consider the phase angle difference between side A y B voltages at the time of closing the breaker, taking into account its operating time through the **Breaker Closing Time** setting and the phase shift angle between sides A and B. Thus, the following phase difference will be added to the phase shift angle between side A and B voltages:

$$\frac{Tclosing(ms)}{1000} \cdot 360 \cdot \left(f_A - f_B \right)$$

where *Tclosing* is the breaker closing time, f_A is the frequency of side A voltage and f_B is the frequency of side B voltage.

In this way, if side A voltage rotates faster than side B ($f_A > f_B$), the above phase shift will be positive, whereas if side A voltage rotates slower than side B ($f_A < f_B$) the phase angle correction to take into account will be negative.

3.10.4 Frequency Difference Element

This element picks up when the frequency difference between the signals of sides A and B is less than the pickup (100% of the setting), and resets when this difference is greater than the setting + 0.01 Hz.

A and **B Side** signal angles are already compensated values according to Table 3.10-1.

3.10.5 Voltage Element of Sides A and B

This element is comprised of two overvoltage elements (for **Sides A** and **B** respectively). Each overvoltage element picks up when the RMS value of the input voltage exceeds 100% of the pickup value (set value) and resets when it is below 95% of this value. The voltages used are values standardized as line-to-neutral voltages.

The voltage element of **sides A** and **B** has two outputs that indicate the presence of voltage on each of the sides.

These outputs are generated whether they have been selected or not with the **Energization** setting, whose only function is to set the combinations to detect synchronism.

3.10.6 Selection of Type of Synchronism

The Recloser as well as the command algorithm (for closing maneuvers of the breaker) use the **SYNC_R** signal, which indicates the presence or absence of synchronism prior to resetting the breaker.

This information can be supplied to the **6IRV** by the output of the IED's own synchronism unit (**SYNC_CALC** signal) or by the digital input of **External Synchronism** (**IN_SYNC_EXT** signal). The setting that determines the origin of the synchronization signal is the **Type of Synchronism** (**SEL_SYNC**).

The activation of the **Blocking Due to Fuse Failure** (**BLK_FF**) signal can cancel the **SYNC_R** signal if the **Synchronism Blocking Due to Fuse Failure** setting (**BLK_SYNC_FF**) is set to **YES**. Thus, closures which could occur without conditions of synchronism are avoided, since the fuse failure would generate a dead-line condition, which could automatically activate the **SYNC_R** signal (if the synchronism is external as well as if calculated) according to the **Energization** setting.

The logic diagram which defines the synchronism signal (**SYNC_R**) is shown in Figure 3.10.2.

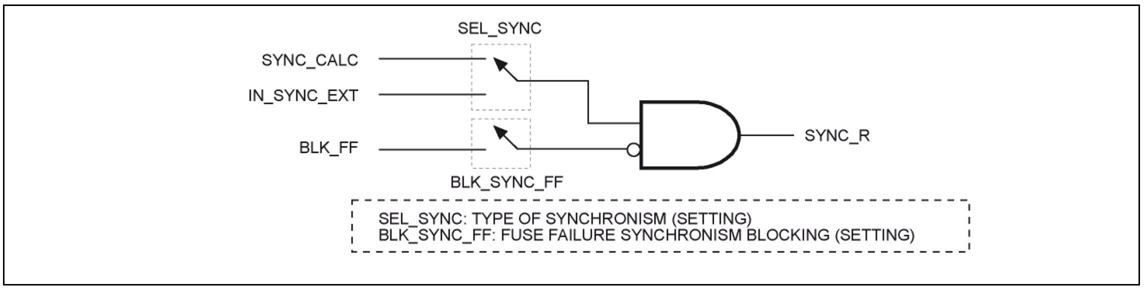


Figure 3.10.2: Block Diagram to Obtain the Synchronism Signal.

3.10.7 Synchronism Elements (6IRV-A**-*****2* or Higher)

Models **6IRV-A** with digit **X9=2** or higher incorporate two synchronism check elements, the function of which is to verify whether the conditions at both ends of the supervised breaker are suitable to closing it (either by reclose or manual reset) and that there will be no oscillations.

In order to be able to supervise that the breaker is synchronized, **6IRV-A**-*****2*** or higher relays include two synchronism elements designated as element 1 and element 2, intended to supervise the closures through the recloser and the manual closing of the breaker respectively.

3.10.7.a Configurating the Voltage of the two Voltage Sides (A and B)

Side A voltage may correspond to A, B or C phases as a function of the line side transformer state. On the other hand, also, **side B** voltage can correspond with A, B or C phase voltages or AB, BC or CA phase to phase voltages as a function of the busbar side transformer state. In order to compare this voltage with **side A** voltage, both **Side A Voltage** and **Side B** voltage configuration settings must adequately be specified. This latter setting, **Side B** setting, will be taken into account to make an angular compensation so that **Side B** voltage can be compensated, as far as the angle is concerned, with **Side A** voltage.

The angle compensation of the **Side B** voltage will continue to be applied in the same way as that mentioned above, but the standardization of modules and compensation of angles is done according to the following table.

For example, if the voltage of side A is **A Phase** voltage and the voltage of side B is **B Phase** voltage, angle compensation for ABC sequence systems will be 120º; if system sequence is ACB, compensation will be 240º. Table 3.10-4 lists all angle compensation possibilities:

Table 3.10-4:Angle Compensation (Phase Sequence)

Side A	Side B voltage setting	ABC Sequence	ACB Sequence
V_A	V_A	0º	0º
V_A	V_B	120º	240º
V_A	V_C	240º	120º
V_A	V_{AB}	330º	30º
V_A	V_{BC}	90º	270º
V_A	V_{CA}	210º	150º
V_B	V_A	240º	120º
V_B	V_B	0º	0º
V_B	V_C	120º	240º
V_B	V_{AB}	210º	150º
V_B	V_{BC}	330º	30º
V_B	V_{CA}	90º	270º
V_C	V_A	120º	240º
V_C	V_B	240º	120º
V_C	V_C	0º	0º
V_C	V_{AB}	90º	270º
V_C	V_{BC}	210º	150º
V_C	V_{CA}	330º	30º

3.10.7.b Sides A and B Voltage Elements

These elements consist of two overvoltage elements and two undervoltage elements. Based on these four settings, three different voltage bands will be determined, three for Side A (Line) and three for Side B (Busbar).

For live line or busbar detection, each overvoltage element, picks up when the rms of the input voltage exceeds 100% of the pickup value (setting value) and resets when it is below 95% of this value. The voltages used are standard phase voltages.

For dead line or busbar detection, each undervoltage element picks up when the rms of the input voltage is below 100% of the pickup value (setting value) and resets when it exceeds 95% of this value. The voltages used are standard phase voltages.

The voltage elements intended to detect whether **Sides A** and **B** are live or dead are provided with 4 outputs that show the following signals for each side of each breaker.

- **Live line**: This signal will activate when the line voltage (SIDE A) ≥ Live line setting set to live.
- **Dead line**: This signal will activate when the line voltage (SIDE A) < Dead line setting.
- **Live bus**: This signal will activate when the busbar voltage (SIDE B) ≥ Live bus setting.
- **Dead bus**: This signal will activate when the busbar voltage (SIDE B) < Dead bus setting.

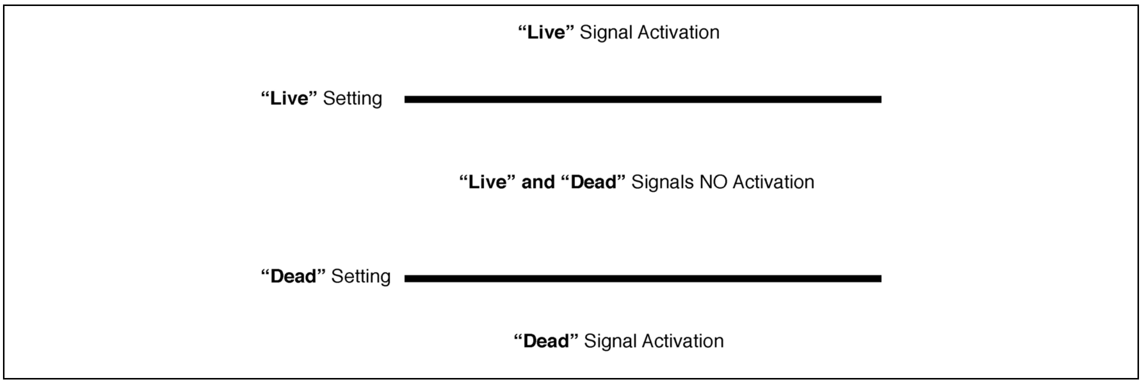


Figure 3.10.3: Activation thresholds to determine Live Line / Dead Line and Live Bus / Dead Bus.

These outputs are generated whether they have of have not been selected through the **Energization** setting, whose sole function is to set the combinations to be used to detect synchronism. This will occur provided we are in the live or dead zone, since if the voltage at any side of the breaker is in the **No activation of "Live" and "Dead" Signals** zone, shown in figure 3.10.3, the outputs of the side involved will not be calculated independently from the rest of the synchronism element settings.

3.10.8 Application of the Synchronism Function

The synchronism function is used to monitor the connection of the two parts of the circuit by the reset of a breaker. It verifies that the voltages on both sides of the breaker ($V_{SIDE\ A}$ and $V_{SIDE\ B}$) are within the magnitude, angle and frequency limits established in the settings.

Verification of synchronism is defined as the comparison of the voltage difference of two circuits with different sources to be joined through an impedance (transmission line, feeder, etc.), or connected with parallel circuits of defined impedances. The voltages on both sides of a breaker are compared before executing its reset so as to minimize possible internal damage due to the voltage difference in phase, as well as magnitude and angle. This is very important in steam-powered power plants where the reclosings of the output lines with considerable angle differences can cause very serious damage to the shaft of the turbine.

The difference in voltage level and phase angle at a given point in time is the result of the load existing between remote sources connected through parallel circuits (load flow). It is also a consequence of the impedance of the elements that join them (even when there is no load flow in the parallel circuits or because the sources to connect to each other are totally independent and isolated from each other).

In meshed systems, the angle difference between two ends of an open breaker is not normally significant since their sources are joined remotely by other elements (equivalent or parallel circuits). Nevertheless, in isolated circuits, as in the case of an independent generator, the angle difference, the voltage levels and the relative phase shift of the voltage phasors can be very considerable. The relative phase shift of their voltages can even be very small or null in such a way that they will be in phase very infrequently. Due to the changing conditions of an electricity system (connection-disconnection of loads, sources and new inductive-capacitive elements) the relative phase shift of one phasor in respect of the other is not null, making synchronization necessary.

In the first case, although the length of the line whose ends (sources) will be connected to determine the angle difference between them should be considered, this is not sufficient to set the synchronism conditions before closing the breaker. Experience indicates that the angle difference window between voltage phasors must be set to 15º-20º.

3.10.9 Synchronism Unit Settings

Synchronism Unit			
Setting	**Range**	**Step**	**By default**
ED Supervision for VSINC Selection (6IRV-B)	YES / NO		NO
Enable	YES / NO		NO
Synchronism type	0: External 1: Internal (Calculated)		0: External
Side B Voltage	V_A / V_B / V_C / V_{AB} / V_{BC} / V_{CA}		V_A
Side B voltage compensation factor (K_{LB})	0.1 - 4	0.01	1
Fuse failure synchronism blocking	YES / NO		NO
Breaker closing time compensation	YES / NO		NO
Breaker closing time	5 - 1000 ms	5 ms	100 ms
Synchronism output time delay	0.00 - 300 s	0.01 s	0 s
Voltage supervision elements enable	YES / NO		NO
Side A voltage elements pickup	20 - 200 V	1 V	20 V
Side B voltage elements pickup	20 - 200 V	1 V	20 V
Energization mask No voltage side A, No voltage side B No voltage side A, Voltage side B Voltage side A, No voltage side B Voltage side A, Voltage side B	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz

- **Synchronism Unit: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**8 - SYNCROCHECK**
3 - INFORMATION	…	…

0 - FUSE FAILURE	**0 - SYNC ENABLE**
…	**1 - TYPE OF SYNC**
8 - SYNCROCHECK	**2 - BUSBAR SELECTION**
…	**3 - BUS VOLT. COMPENS.**
	4 - VOLTAGE SUPRV ENBL
	5 - SIDE A VOLT. PU
	6 - SIDE B VOLT. PU
	7 - ENERGIZATION MASK
	8 - VOLT. DIFF. ENABLE
	9 - MAX. VOLTAGE DIFF.
	10 - PHASE DIFF. ENABLE
	11 - MAX. PHASE DIFF.
	12 - FREQ. DIFF. ENABLE
	13 - MAX. FREQ. DIFF.
	14 - SYNC DELAY
	15 - FF SYNC. BLOCK
	16 - BRK CLOSE T COMP
	17 - BRK CLOSE T

6IRV-B MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**8 - SYNCROCHECK**
3 - INFORMATION	…	…

0 - FUSE FAILURE	
…	**0 - DI SUPERV VSYN SEL**
8 - SYNCROCHECK	**1 - I1**
…	**2 - I2**

0 - DI SUPERV VSYN SEL	**0 - SYNC ENABLE**
1 - I1	**1 - TYPE OF SYNC**
2 - I2	**2 - BUSBAR SELECTION**
	3 - BUS VOLT. COMPENS.
	4 - VOLTAGE SUPRV ENBL
	5 - SIDE A VOLT. PU
	6 - SIDE B VOLT. PU
	7 - ENERGIZATION MASK
	8 - VOLT. DIFF. ENABLE
	9 - MAX. VOLTAGE DIFF.
	10 - PHASE DIFF. ENABLE
	11 - MAX. PHASE DIFF.
	12 - FREQ. DIFF. ENABLE
	13 - MAX. FREQ. DIFF.
	14 - SYNC DELAY
	15 - FF SYNC. BLOCK
	16 - BRK CLOSE T COMP
	17 - BRK CLOSE T

3.10.10 Synchronism Units Settings (6IRV-A**-*****2 or Higher)

Synchronism Unit			
Setting	**Range**	**Step**	**By default**
Synchronism Type	0: External 1: Internal (Calculated)		0: Internal
Line Selection	V_A / V_B / V_C		V_A
Busbar Selection	V_A / V_B / V_C / V_{AB} / V_{BC} / V_{CA}		V_A
Side B Voltage Compensation Factor (K_{LB})	0.1 - 4	0.01	1
Voltage supervision elements enable	YES / NO		NO
Live Line	0 - 200 V	1 V	51 V
Dead Line	0 - 200 V	1 V	19 V
Live Bus	0 - 200 V	1 V	51 V
Dead Bus	0 - 200 V	1 V	19 V
Breaker Close Time Compensation	YES / NO		NO
Breaker Close Time	5 - 1000 ms	5 ms	100 ms
Unit 1			
Synchronism Enable	YES / NO		NO
Energization mask D BUS / D LINE H BUS / D LINE D BUS / H LINE H BUS / H LINE	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz
Synchronism Delay	0.00 - 300 s	0.01 s	0 s
Fuse Failure Synchronism Blocking	YES / NO		NO
Unit 2			
Synchronism Enable	YES / NO		No
Energization mask D BUS / D LINE H BUS / D LINE D BUS / H LINE H BUS / H LINE	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz
Synchronism Delay	0.00 - 300 s	0.01 s	0 s
Fuse Failure Synchronism Blocking	YES / NO		NO

- **Synchronism Unit: HMI Access (6IRVA-***-*****2* or Higher)**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS		…
2 - CHANGE SETTINGS	0 - GENERAL	**8 - SYNCROCHECK**
3 - INFORMATION	**1 - PROTECTION**	…
	…	

0 - FUSE FAILURE	**1 - LINE SELECTION**
…	**2- BUSBAR SELECTION**
8 - SYNCROCHECK	**3 - BUS VOLT. COMPENS.**
…	**4 - VOLTAGE SUPRV ENBL**
	5 - LIVE LINE
	6 - DEAD LINE
	7 - LIVE BUS
	8 - DEAD BUS
	9 - BRK CLOSE T COMP
	10 - BRK CLOSE T
	11 - UNIT 1
	12 - UNIT 2

10 - BRK CLOSE T	**0 - SYNC ENABLE**
11 - UNIT 1	**1 - ENERGIZATION MASK**
12 - UNIT 2	**2 - VOLT. DIFF. ENABLE**
	3 - MAX. VOLTAGE DIFF.
	4 - PHASE DIFF. ENABLE
	5 - MAX. PHASE DIFF.
	6 - FREQ. DIFF. ENABLE
	7 - MAX. FREQ. DIFF.
	8 - SYNC DELAY
	9- FF SYNC. BLOCK

3.10.11 Digital Inputs and Events of the Synchronism Module

Table 3.10-5: Digital Inputs and Events of the Synchronism Module		
Name	**Description**	**Function**
INBLK_SYNC	Close synchronism block input (6IRV-A)	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
INBLK_SYNC1	Close 1 synchronism block input (6IRV-B) Close synchronism unit 1 block input (6IRV-A**-*****2*)	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
INBLK_SYNC2	Close synchronism block input (6IRV-B) Close synchronism unit 2 block input (6IRV-A**-*****2*)	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
ENBL_SYNC	Close synchronism enable input (6IRV-A)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_SYNC1	Close 1 synchronism enable input (6IRV-B) Close synchronism enable input unit 1 (6IRV-A**-*****2*)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_SYNC2	Close 2 synchronism enable input (6IRV-B) Close synchronism enable input unit 2 (6IRV-A**-*****2*)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

Table 3.10-5: Digital Inputs and Events of the Synchronism Module		
Name	**Name**	**Name**
IN_SYNC_EXT	External synchronism input (6IRV-A)	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_SYNC_EXT1	External 1 synchronism input (6IRV-B) External synchronism input unit 1 (6IRV-A**-*****2*)	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_SYNC_EXT2	External 2 synchronism input (6IRV-B) External synchronism input unit 2 (6IRV-A**-*****2*)	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_89B1_OP	Tie Breaker 1 Open (6IRV-B)	Its activation means that the normally closed tie breaker 1 state contact is closed
IN_89B2_OP	Tie Breaker 2 Open (6IRV-B)	Its activation means that the normally closed tie breaker 2 state contact is closed

3.10.12 Digital Outputs and Events of the Synchronism Module

Table 3.10-6: Digital Outputs and Events of the Synchronism Module		
Name	**Description**	**Function**
SYNC_CALC	Synchronism unit activation (6IRV-A)	The synchronism unit determines that there are overall close conditions.
SYNC1_CALC	Synchronism 1 unit activation (6IRV-B) Synchronism 1 unit activation (6IRV-A**-*****2*)	The synchronism 1 unit determines that there are overall close conditions.
SYNC2_CALC	Synchronism 2 unit activation (6IRV-B) Synchronism 2 unit activation (6IRV-A**-*****2*)	The synchronism 2 unit determines that there are overall close conditions.
P_SYNC_DPH	Permission to close by phase difference (6IRV-A)	The synchronism unit determines that there are close conditions by the phase difference criterion.
P_SYNC1_DPH	Permission to close breaker 1 by phase difference (6IRV-B) Permission to close unit 1 by phase difference (6IRV-A**-*****2*)	The synchronism 1 unit determines that there are close conditions by the phase difference criterion.
P_SYNC2_DPH	Permission to close breaker 2 by phase difference (6IRV-B) Permission to close unit 2 by phase difference (6IRV-A**-*****2*)	The synchronism 2 unit determines that there are close conditions by the phase difference criterion.
P_SYNC_DF	Permission to close by frequency difference (6IRV-A)	The synchronism unit determines that there are close conditions by the frequency difference criterion.
P_SYNC1_DF	Permission to close breaker 1 by frequency difference (6IRV-B) Permission to close unit 1 by frequency difference (6IRV-A**-*****2*)	The synchronism 1 unit determines that there are close conditions by the frequency difference criterion.
P_SYNC2_DF	Permission to close breaker 2 by frequency difference (6IRV-B) Permission to close unit 2 by frequency difference (6IRV-A**-*****2*)	The synchronism 2 unit determines that there are close conditions by the frequency difference criterion.
P_SYNC_DV	Permission to close by voltage difference (6IRV-A)	The synchronism unit determines that there are close conditions by the voltage difference criterion.
P_SYNC1_DV	Permission to close breaker 1 by voltage difference (6IRV-B) Permission to close unit 1 by voltage difference (6IRV-A**-*****2*)	The synchronism 1 unit determines that there are close conditions by the voltage difference criterion.
P_SYNC2_DV	Permission to close breaker 2 by voltage difference (6IRV-B) Permission to close unit 2 by voltage difference (6IRV-A**-*****2*)	The synchronism 2 unit determines that there are close conditions by the voltage difference criterion.
P_SYNC_EL	Permission to close by energization on the sides (6IRV-A)	The synchronism unit determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.

Table 3.10-6: Digital Outputs and Events of the Synchronism Module		
Name	Name	Name
P_SYNC1_EL	Breaker 1 permission to close by energization on the sides (6IRV-B) Unit 1 permission to close by energization on the sides (6IRV-A**-*****2*)	The synchronism 1 unit determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
P_SYNC2_EL	Breaker 2 permission to close by energization on the sides (6IRV-B) Unit 2 permission to close by energization on the sides (6IRV-A**-*****2*)	The synchronism 2 unit determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
SYNC_R	Close by synchronism enabled (6IRV-A)	It is the signal that the recloser receives to monitor the close by synchronism. Its activation indicates that there is permission, and depending on how the selector is set, it will be external or calculated synchronism.
SYNC1_R	Breaker 1 close by synchronism enabled (6IRV-B) Unit 1 close by synchronism enabled (6IRV-A**-*****2*)	It is the signal that the recloser receives to monitor the breaker 1 close by synchronism. Its activation indicates that there is permission, and depending on how the selector is set, it will be external or calculated synchronism.
SYNC2_R	Breaker 2 close by synchronism enabled (6IRV-B) Unit 2 close by synchronism enabled (6IRV-A**-*****2*)	It is the signal that the recloser receives to monitor the breaker 2 close by synchronism. Its activation indicates that there is permission, and depending on how the selector is set, it will be external or calculated synchronism.
SYNC_ENBLD	Close synchronism enabled (6IRV-A)	Indication of enabled or disabled status of the unit.
SYNC1_ENBLD	Breaker 1 close synchronism enabled (6IRV-B) Unit 1 close synchronism enabled (6IRV-A**-*****2*)	Indication of enabled or disabled status of the unit.
SYNC2_ENBLD	Breaker 2 close synchronism enabled (6IRV-B) Unit 2 close synchronism enabled (6IRV-A**-*****2*)	Indication of enabled or disabled status of the unit.
V_SIDE_A	Voltage on side A (6IRV-A)	It indicates presence of voltage on side A.
V_SIDE_A1	Voltage on side A breaker 1 (6IRV-B)	It indicates presence of voltage on side A of breaker 1.
V_SIDE_A2	Voltage on side A breaker 2 (6IRV-B)	It indicates presence of voltage on side A of breaker 2.
V_SIDE_B	Voltage on side B (6IRV-A)	It indicates presence of voltage on side B.
V_SIDE_B1	Voltage on side B breaker 1 (6IRV-B)	It indicates presence of voltage on side B of breaker 1.
V_SIDE_B2	Voltage on side B breaker 2 (6IRV-B)	It indicates presence of voltage on side B of breaker 2.

Table 3.10-6: Digital Outputs and Events of the Synchronism Module

Name	Name	Name
LIVELINE1	Voltage on side A of the breaker (6IRV-A**-*****2*)	It indicates presence of voltage on side A of the breaker
DEADLINE1	No Voltage on side A of the breaker (6IRV-A**-*****2*)	Indicates absence of voltage on side A of the breaker.
LIVEBUS1	Voltage on side B of the breaker (6IRV-A**-*****2*)	It indicates presence of voltage on side B of the breaker.
DEADBUS1	No Voltage on side B of the breaker (6IRV-A**-*****2*)	Indicates absence of voltage on side B of the breaker.
INBLK_SYNC	Close synchronism block input (6IRV-A)	The same as for the Digital Input.
INBLK_SYNC1	Close synchronism breaker 1 block input (6IRV-B) Close synchronism unit 1 block input (6IRV-A**-*****2*)	The same as for the Digital Input.
INBLK_SYNC2	Close synchronism breaker 2 block input (6IRV-B) Close synchronism unit 2 block input (6IRV-A**-*****2*)	The same as for the Digital Input.
ENBL_SYNC	Close synchronism enable input (6IRV-A)	The same as for the Digital Input.
ENBL_SYNC1	Close synchronism breaker 1 enable input (6IRV-B) Close synchronism unit 1 enable input (6IRV-A**-*****2*)	The same as for the Digital Input.
ENBL_SYNC2	Close synchronism breaker 2 enable input (6IRV-B) Close synchronism unit 2 enable input (6IRV-A**-*****2*)	The same as for the Digital Input.
IN_SYNC_EXT	External synchronism input (6IRV-A)	The same as for the Digital Input.
IN_SYNC_EXT1	External synchronism breaker 1 input (6IRV-B) External synchronism unit 1 input (6IRV-A**-*****2*)	The same as for the Digital Input.
IN_SYNC_EXT2	External synchronism breaker 2 input (6IRV-B) External synchronism unit 2 input (6IRV-A**-*****2*)	The same as for the Digital Input.
IN_89B1_OP	Tie Breaker 1 Open (6IRV-B)	The same as for the Digital Input.
IN_89B2_OP	Tie Breaker 2 Open (6IRV-B)	The same as for the Digital Input.

CAUTION!

If, while the Permission (Enable) setting is YES, the four bits of the energization mask are set to NO, the voltage element is deactivated and, consequently, the synchronism unit. Therefore, if you want to disable the voltage element of sides A and B, set that element's Permission to NO and not the four bits of the energization mask.

3.10.13 Synchronism Unit Test

To verify this unit, first the protection units are disabled. Then, the system is prepared to measure the time between the injection of the voltage and the activation of the Synchronism Unit. Lastly, the signals indicated in Table 3.10-7 are checked.

Table 3.10-7:Output Configuration

Logic signal	Description of logic signal
SINC_CALC	Activation of the synchronism unit
Side A Voltage	Voltage on side A detected
Side B Voltage	Voltage on side B detected

3.10.13.a Voltage Elements Test

Disable the Voltage Difference, Phase Difference and Frequency Difference elements. The Synchronism Unit is set as follows:

Synchronism enable	**YES**
Type of synchronism	**1: Internal**
Side B voltage	**1: VB**
Fuse failure synchronism blocking	**NO**
Side B voltage compensation factor (KLB)	**1**

- **Voltage Supervision Element**

Enable	**YES**
Side A detection pickup	**25 V**
Side B detection pickup	**25 V**
Energization masks	
No voltage side A; No voltage side B	**NO**
No voltage side A; Voltage side B	**YES**
Voltage side A; No voltage side B	**YES**
Voltage side A; Voltage side B	**NO**

- **Voltage Difference Element**

Enable	**YES**
Maximum voltage difference	**10%**

- **Phase Difference Element**

Enable	**YES**
Maximum phase difference	**20º**

- **Frequency Difference Element**

Enable	**YES / NO**
Maximum frequency difference	**0.20 Hz**
Synchronism output time delay	**0.00s**

- **Pickups**

Three tests should be performed for each of the three different pickup settings. Apply a voltage of 15 Vac with a phase angle of 0º to phase A, and apply 65 Vac with a phase angle of 0º to voltage side B (bus voltage). Synchronism Unit should activate.

Increase the voltage of phase A until the synchronism unit is deactivated. The voltage at which it is deactivated should be within the ranges shown in Table 3.10-8 for the corresponding pickup setting.

Table 3.10-8:Pickup and Reset of the Voltage Units

Pickup Setting (V)	Pickup Value (V)		Dropout Value (V)	
	Minimum	Maximum	Minimum	Maximum
25	24.25	25.75	23.04	24.46
45	43.65	46.35	41.47	44.03
60	58.20	61.80	55.29	58.71

The dropout should take place instantaneously within the ranges shown in Table 3.10-8, corresponding to the setting used.

3.10.13.b Voltage Difference Element Test

Enable the Voltage Difference element, and disable the Voltage, Phase Difference and Frequency Difference elements.

- **Pickup**

Three tests should be performed for each of the three different pickup settings.

A voltage of 30 Vac and phase 0º is applied to phase A and of 65 Vac and phase 0º to the voltage channel of side B. All the outputs must deactivate.

Increase the voltage of phase A until Synchronism element is activated and stable. The voltage where this activation occurs should be within the ranges shown in Table 3.10-9 for the corresponding pickup setting.

The dropout should take place instantaneously within the ranges shown in Table 3.10-9, corresponding to the setting used.

Table 3.10-9:Pickup and Reset of The Voltage Difference Unit

Pickup Setting (p.u.)	Pickup Value (V)		Dropout Value (V)	
	Minimum	Maximum	Minimum	Maximum
10%	56.75	60.26	56.42	59.92
20%	50.44	53.56	49.81	52.89
30%	44.14	46.87	43.19	45.87

3.10.13.c Phase Difference Element Test

Enable the Phase Difference element, and disable the Voltage, Voltage Difference and Frequency Difference elements.

- **Pickup**

Three tests should be performed for each of the three different pickup settings.

Apply a voltage of 65 Vac with a phase angle of 50º to phase A, and apply 65 Vac with a phase angle of 0º to the voltage side B (bus voltage).

Reduce the angle of the voltage of phase A, until Synchronism element is activated and stable. The angle where this activation occurs should be within the ranges shown in Table 3.10-10 for the corresponding pickup setting.

The dropout should take place instantaneously within the ranges shown in Table 3.10-10, corresponding to the setting used.

Table 3.10-10:Pickup and Reset Of The Phase Difference Unit

Pickup Setting (º)	Pickup Value (º)		Dropout Value (º)	
	Minimum	Maximum	Minimum	Maximum
20	19	21	21	23
30	29	31	31	33
40	39	41	41	43

- **Breaker Closing Time Compensation**

Set the phase angle difference element to 20º. Set to **YES** the **Breaker Closing Time Compensation Enable** setting. Set the **Breaker Closing Time** to 50 ms.

Inject VA=65 0º and VSINC=65 30º, both at 50 Hz. Change VSINC voltage frequency to 51 Hz. Given the frequency difference between the voltages at both sides of the breaker, during its closing time, voltage VSINC, rotating faster than voltage VA, will have a shift of 18º

$$\frac{Tclosing(ms)}{1000} \cdot 360 \cdot \left(f_A - f_B\right)$$

where $T_{closing}$ is breaker closing time, f_A is VA frequency and f_B is VB frequency). Thus, check that the phase difference element picks up when VSINC lags 37º to 39º relative to VA and resets when VSINC leads 1º to 3º relative to VA.

3.10.13.d Frequency Difference Element Test

Enable the Frequency Difference element and disable the remaining elements.

- **Pickup**

Three tests should be performed for each of the pickup settings.

Apply a voltage of 65 Vac with a phase angle of 0º and a frequency of 53 Hz to phase A, and apply 65 Vac with a phase angle of 0º and a frequency of 50 Hz to voltage side B (bus voltage). All the outputs must deactivate.

Reduce the frequency of the voltage to phase A until Synchronism element is active and stable. The frequency where this occurs should be within the ranges shown in Table 3.10-11 for the corresponding pickup setting. The dropout should take place instantaneously within the ranges shown in Table 3.10-11, corresponding to the setting used.

Table 3.10-11:Pickup and Reset of the Frequency Difference Unit

Pickup Setting (Hz)	Pickup Difference (Hz)		Dropout Difference (Hz)	
	Minimum	Maximum	Minimum	Maximum
0.20	0.19	0.21	0.20	0.22
1.00	0.97	1.03	0.98	1.04
2.00	1.94	2.06	1.95	2.07

3.10.13.e Time Settings Test

Three tests should be performed for three different pickup settings (0.10s, 1s and 10s).

Prepare the system to measure the time between the application of voltage and the close of the contact of the Synchronism element.

Only the voltage difference unit is enabled between **Sides A** and **B**.

A voltage of 65 V and 0º is applied to phase A and to the voltage channel of side B. The synchronism unit must activate within the margin of ±1% of the setting or ±20ms.

The angle to add to the phase displacement between VA and VSINC is -1.8 º. Verify that the pick up of this element is at an angle of VSINC of 356.8 º.

Note: in the model 6IRV-B, the B Side Voltage of the Synchronism Units of circuit breakers 1 and 2 will be VSINC and VSINC2 respectively.

3.11 Dead Line Detector

3.11.1 Operating Principles

6IRV relays incorporate a Dead Line Detection element to detect deenergized line condition with no need for supervising any physical digital input. This is based on the operation of one undercurrent and one undervoltage elements the pickup values of which are given by the **Current level** and **Voltage level** settings respectively. Said elements activate at 95% of the pickup setting and reset at 100% of said setting.

The Dead Line Detector can be applied only when the voltage transformer is on the line side.

The Dead Line Detector blocks when the **Fuse Fail Block** signal (**BLK_FF**) activates, given the lack of reliability of undervoltage detectors on fuse failure conditions. Figure 3.11.1 Logic diagram of the Dead Line Detector, shows the operation of this element.

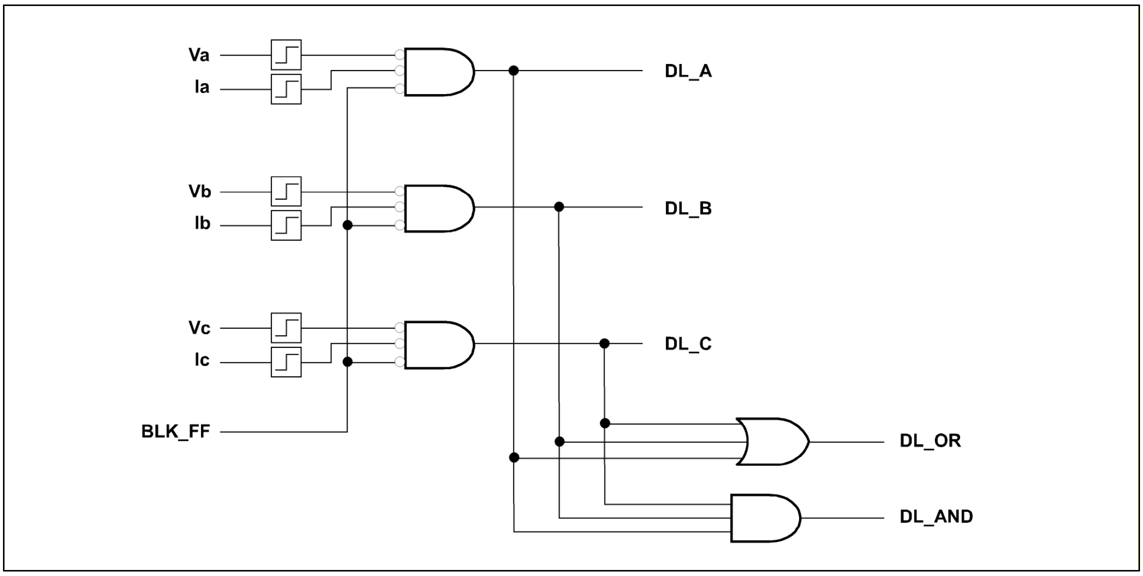


Figure 3.11.1: Logic Diagram of the Dead Line Detector.

3.11.2 Dead Line Detector Settings

Dead Line Detector			
Setting	**Range**	**Step**	**By default**
Dead line detector enable signal	YES / NO		NO
Dead line current level	0.2 - 4 A	0.01 A	0,2 A
Dead line voltage level	2 - 70 V	0.01 V	45 V

- **Dead Line Detector: HMI Access**

0 - CONFIGURATION		
1 - OPERATIONS	0 - GENERAL	0 - FUSE FAILURE
2 - CHANGE SETTINGS	**1 - PROTECTION**	**1 - DEAD LINE DETECTOR**
3 - INFORMATION	...	...

0 - FUSE FAILURE	**0 - DL DETEC ENABLE**
1 - DEAD LINE DETECTOR	**1 - CURRENT LEVEL**
	2 - VOLTAGE LEVEL

3.11.3 Digital Inputs and Events of the Dead Line Detector

Table 3.11-1: Digital Inputs and Events of the Dead Line Detector

Name	Description	Function
ENBL_DL	Dead line detector enable input	Its activation sets the element into operation. It can be assigned to a level digital input or communications protocol or HMI command. Default value of this logic input is "1".

3.11.4 Digital Outputs and Events of the Dead Line Detector

Table 3.11-2: Digital Outputs and Events of the Dead Line Detector

Name	Description	Function
DL_A	Dead Phase A	Indication of phase A deenergized.
DL_B	Dead Phase B	Indication of phase B deenergized.
DL_C	Dead Phase C	Indication of phase C deenergized.
DL_OR	Any Dead Phase	Indication of any phase deenergized
DL_AND	Three Dead Phases	Indications of three-phases deenergized
DL_ENBLD	Dead line detector enabled	Indication of element enabled or disabled state.
ENBL_DL	Dead line detector enable input	The same as for the digital input.

3.12 VT Fuse Failure Detector

3.12.1 Operating Principles

If the VT secondary circuit fuses blow, the terminal unit will lose the corresponding voltage analog input. This situation may cause unwanted operation of the distance elements. Therefore, this condition must be detected and the measuring elements must be blocked before undesired tripping occurs.

The fuse failure condition is detected when one of the three phase voltages drops below of the **Voltage Level** setting value. On not involving this phenomenon at the currents, there will not be a fault detection, for which the output of this detector (**FD**) is used (see 3.2, Fault Detector) as discriminator.

The opening of any pole of the breaker will generate a fuse failure condition if the voltage transformer is on the line side, for which the output of **Any Open Pole** (**OR_P_OP**) originating from the **Open Pole Detector** blocks the activation of the Fuse Failure Detector.

On the other hand, the Fuse Failure unit is disabled if the value of the positive sequence current is below 0.05*In A.

VT Fuse Failure Detection operation is shown in Figure 3.12.1.

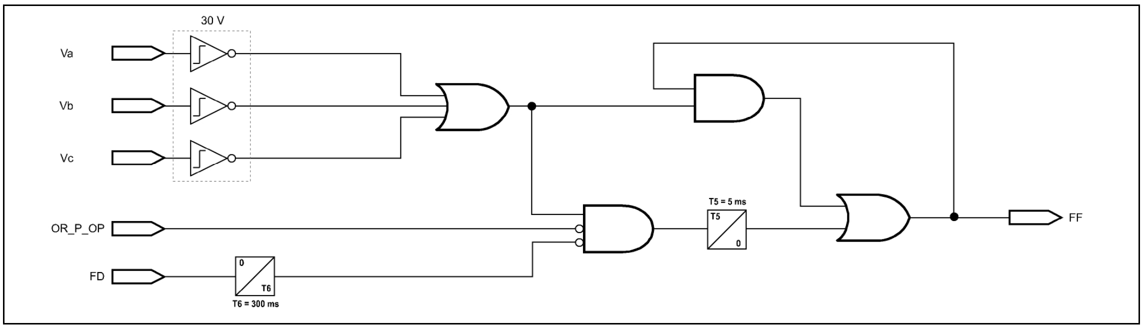


Figure 3.12.1: VT Fuse Failure Detector Block Diagram.

Undervoltage detectors pick up when this voltage is lower than 95% of the setting **Voltage Level** and reset when it is greater than 100% of said voltage.

The output of the Fuse Failure unit will generate **Blocking due to Fuse Failure** (**BLK_FF**) output if **Blocking Due to Fuse Failure** is set at **YES**. This last output will always block the activation of all the distance units and may block the activation of other units based on the voltage measurement, such as Undervoltage Units or Synchronism Unit, if the corresponding blocking settings are enabled.

The **Fuse Failure** (**IN_FF**) digital input, originating from the contact position of a voltage thermalmagnetic circuit breaker, is another possibility which exists to detect the fuse failure condition. The activation of this input will always generate **Blocking due to Fuse Failure** output, originating from the enable and/or blocking adjustments of the Fuse Failure unit. The activation of the **Fuse Failure** digital input presents a fall time adjustment (**Fuse Failure Input Time**), in order to maintain the blocking of the units on which acting during the voltage reset transient.

The logic scheme encompasses the two possibilities of blocking due to fuse failure:

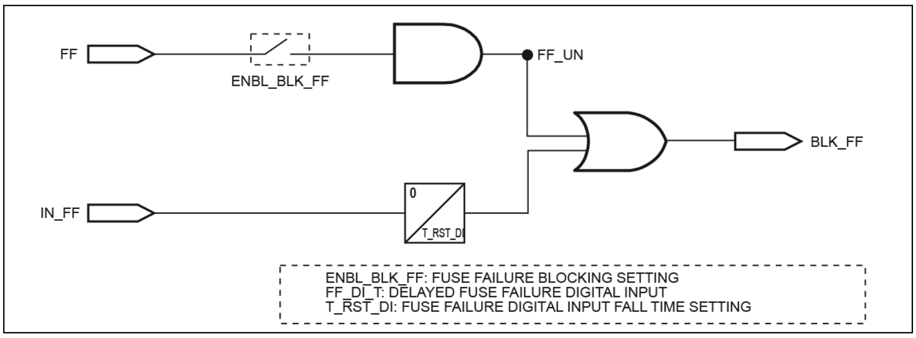


Figure 3.12.2: Logic Diagram of Blocking Due to Fuse Failure.

When a fuse failure condition arises, the distance units as well as directional units, supervisors of the overcurrent elements without **Torque Control** setting at **NO**, they do not have the necessary voltage to be polarized, for which they cannot act if there is a failure in this situation. In order to have an emergency non-directional overcurrent element, provided one does not already exist, the directional units present the **Blocking due to Lack of Polarization** setting. If this adjustment is set at **NO**, when the necessary voltage to polarize these is not available, they go on to issue actuation permission to the overcurrent units on which they depend, consequently converting these into non-directional.

3.12.2 VT Fuse Failure Detector Settings

VT Fuse Failure Detector			
Setting	**Range**	**Step**	**By default**
Voltage Level	5 - 70 V	0.01 V	30 V
Enable	YES / NO		
Blocking Enable	YES / NO		
Blocking Reset Time	0 - 1000 ms	50 ms	

- **VT Fuse Failure Detector: HMI Access**

0 - CONFIGURATION		
1 - OPERATIONS	0 - GENERAL	
2 - CHANGE SETTINGS	**1 - PROTECTION**	**0 - FUSE FAILURE**
3 - INFORMATION	...	...

0 - FUSE FAILURE	**0 - FF DET ENABLE**
...	**1 - FF BLOCK ENABLE**
	2 - FF INPUT DO DLY
	3 - VOLTAGE LEVEL

3.12.3 Digital Inputs and Events of the VT Fuse Failure Detector

Table 3.12-1: Digital Inputs and Events of the VT Fuse Failure Detector		
Name	**Description**	**Function**
ENBL_FF	VT fuse failure detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
IN_FF	VT fuse failure detector input	The activation of this input directly generates the blocking output due to fuse failure.

3.12.4 Digital Outputs and Events of the VT Fuse Failure Detector

Table 3.12-2: Digital Outputs and Events of the VT Fuse Failure Detector		
Name	**Description**	**Function**
FF	VT fuse failure detector activated	Output of the VT fuse failure detector.
FF_UN	Fuse failure unit blocking	Blocking output due to fuse failure condition detected by the unit itself.
BLK_FF	Fuse failure blocking	Blocking output due to fuse failure condition (detected by the unit itself or by the digital input).
FF_ENBLD	VT fuse failure detector enabled	Indication of enabled or disabled status of the unit.
ENBL_FF	VT fuse failure detector enable input	The same as for the digital input.
IN_FF	VT fuse failure detector input	The same as for the digital input.

3.12.5 VT Fuse Failure Detector Test

Enable the Fuse Failure detector and Blocking and disable all of the other Auxiliary Units. The setting **Voltage Level** will take the default value (30 V).

Table 3.12-3:Output Configuration for the Fuse Failure Detector Test	
AUX-5	Activation of the VT fuse failure detector
AUX-6	VT fuse failure detector blocking

During the test, consult the indicators:

Display In the **Information** - **Status** - **Measuring Elements** - **VT Fuse Failure Detector** screen,
ZIVercomPlus® In the **Status** screen (**Status** - **Elements**- **VT Fuse Failure Detector**).

For this test, apply a three-phase balanced system of voltages and current of 65 Vac with angles of 0º, 120º and 240º; and 1 A ac with inductive angles of 25º, 145º and 265º, respectively. The current will reflect a shift phase with respect to the voltage of 25º inductive.

Simultaneously reduce the voltages of the three-phases to 28.5 Vac (27.64 Vac to 29.35 Vac). The contacts of the outputs AUX-5 and AUX-6 should close and the indicators mentioned previously should activate.

3.13 Phase Selector

3.13.1 Operating Principles

The **6IRV** is provided with a Phase Selector unit whose function is to determine the type of failure to generate the outputs which include this information.

The information on the faulted phases is developed using two algorithms. The first algorithm determines that a three-phase (**3PH_F**) fault is generated if the following conditions are met:

1. **Low negative sequence current**: the presence of a negative sequence current not greater than setting **I2 Level** and a ratio of negative sequence current / positive sequence current no greater than the setting **I2/I1 Factor**.
2. **Low zero sequence current**: the presence of a zero sequence current no greater than setting **I0 Level** and a ratio of zero sequence current / positive sequence current no greater than setting **I0/I1 Factor**.

The percentages of negative and zero sequence current with respect to the positive sequence current avoid erroneous phase selections due to imbalance deriving from a different degree of saturation presented by the current transformers in case of three-phase faults.

It is important to point out that the three-phase indication is associated with a balanced condition, for which it would also arise in a load situation. The Fault Detector (see 3.2) will be in charge of distinguishing the fault condition of a load.

When the detected fault does not satisfy the conditions to be considered a three-phase fault, the second algorithm will be executed, based on the comparison between positive and negative sequence current magnitudes.

When the fault is not three-phase, but the second condition for three-phase faults is satisfied (low zero sequence current component), the fault involves two phases (**2PH_F**). If the second condition is not met (low zero sequence current component), a ground fault has occurred, which could be single-phase or two phases to ground (**GR_F**).

To determine the phases involved, the angle will be examined:

$$\phi = \arg(Ia2) - \arg(Ia1\_f)$$

where:

$Ia2$	Phase A negative sequence current component.
$Ia1\_f$	Phase A positive sequence fault current component (without the load component).

The angle diagrams, used to determine the phases under fault as a function of the angle ϕ, are represented in following figures.

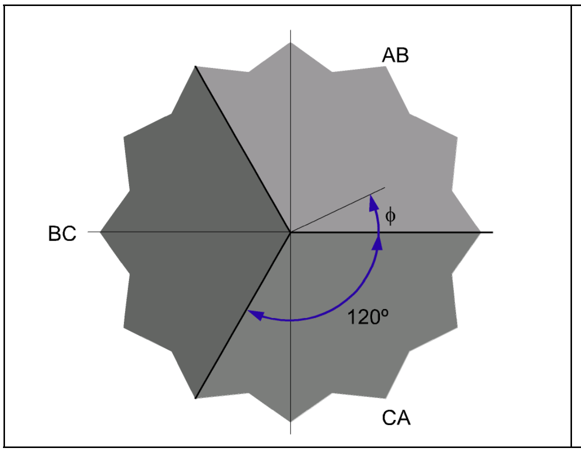


Figure 3.13.1: Two-Phase Fault Angle Diagram.

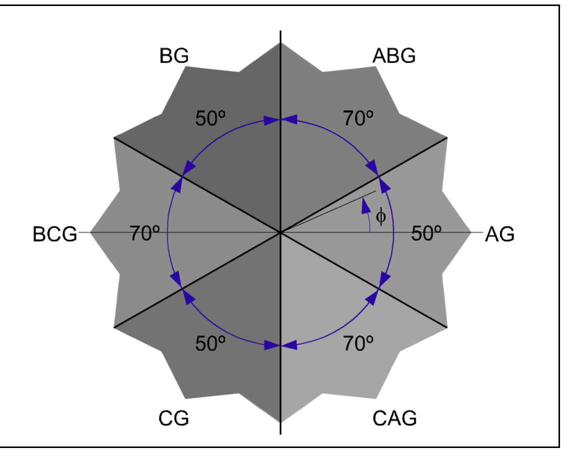


Figure 3.13.2: Single-Phase and Two-Phase- to-Ground Fault Angle Diagram.

The phase selector will not operate if the following two conditions are simultaneously complied with:

1. Presence of positive sequence current not above 0.02*In A.
2. Presence of zero sequence current not above 0.05*In A.

3.13.2 Phase Selection with of Open-Pole Conditions

The opening of a breaker pole, detected through the Open-Pole Detector (see 3.8), creates an imbalance which generates negative and zero sequence components in load conditions. In open pole conditions, when a fault occurs, the Phase Selector will remove prefault currents, to work with fundamental fault currents.

3.13.3 Phase Selector Settings

Phase Selector			
Setting	**Range**	**Step**	**By Default**
Level I0	0.1 - 5 A	0.01 A	0.25 A
Level I2	0.1 - 5 A	0.01 A	0.25 A
I0/I1 Factor	5 - 30	0.1	8
I2/I1 Factor	5 - 30	0.1	10

- **Phase Selector: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**13 - PHASE SELECTOR**
3 - INFORMATION	...	...

0 - FUSE FAILURE	**0 - I0 LEVEL**
...	**1 - I2 LEVEL**
13 - PHASE SELECTOR	**2 - I0/I1 FACTOR**
...	**3 - I2/I1 FACTOR**

6IRV-B MODELS

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**14 - PHASE SELECTOR**
3 - INFORMATION	...	...

0 - FUSE FAILURE	**0 - I0 LEVEL**
...	**1 - I2 LEVEL**
14 - PHASE SELECTOR	**2 - I0/I1 FACTOR**
...	**3 - I2/I1 FACTOR**

3.13.4 Digital Inputs and Events of the Phase Selector

The phase selector does not present any digital input, not even enable, remaining always in operation.

3.13.5 Digital Outputs and Events for the Final Selection of Fault Type

Table 3.13-1: Digital Outputs and Events for the Final Selection of Fault Type

Name	Description	Function
AG_F	AG Fault	Indication of type of fault.
BG_F	BG Fault	
CG_F	CG Fault	
AB_F	AB Fault	
BC_F	BC Fault	
CA_F	CA Fault	
ABG_F	ABG Fault	
BCG_F	BCG Fault	
CAG_F	CAG Fault	
3PH_F	ABC fault	
GR_F	Ground fault	
2PH_F	Two-phase fault	
MULTIPH_F	Polyphase fault	

3.14 Fault Detector

3.14.1 Operating Principles

6IRV terminal units are provided with a Fault Detector to supervise element operation (see 3.17 Tripping Logic). Operation of the Fault Detector is based on Detection of Increases in the Sequence Currents and Detection of Levels Exceeded in the Sequence Current.

3.14.1.a Detection of Increases in the Sequence Currents

The conditions which activate the Fault Detector are the following:

- An increase in the effective value of the **zero sequence current** with respect to the value of two cycles previously higher than **0.04*In A** (ground fault indicative).
- An increase in the effective value of the **negative sequence current** with respect to the two cycle value previously higher than **0.04*In A** (phase fault indicative).
- A percentual increase in the effective value of the **positive sequence current** with respect to the two-cycle value previously higher than 25% (indicative of any fault).

The activation of the Fault Detector based on previously mentioned increases will remain sealed for the duration of two cycles, given that the comparison is made with magnitudes memorized two cycles previously. Notwithstanding, an additional reset time of 30 ms is included.

3.14.1.b Detection of Levels Exceeded in the Sequence Current

The following are the conditions which activate the Fault Detector:

- **Ground fault output** activation originating from the phase selector.
- **Two-phase fault output** activation originating from the phase selector.

An open pole condition excludes the **Ground Fault** and **Two Phase Fault** signals from the fault detector. Otherwise, this situation would activate the detector as long as the pole remains open.

The above algorithms further need at least one of the following conditions to be met:

- Positive sequence current above 0.02*In A.
- Zero sequence current above 0.05*In A.

Zero sequence threshold current supervision allows the Fault Detector to be operative upon faults associated to mainly zero sequence current flow.

The activation of the Fault Detector generated by either of the two previously-mentioned algorithms is kept sealed with the activation of any of the **Overcurrent** Units (**PU_IOC_PHn**, **PU_TOC_PHn**, **PU_IOC_Nn**, **PU_TOC_Nn**, **PU_IOC_NSn**, **PU_TOC_NSn**, see overcurrent units) or as a result of the activation of the **Tripping** signal (**TRIP**).

The operation diagram of the fault detector unit is shown in Figures 3.14.1, 3.14.2 and 3.14.3.

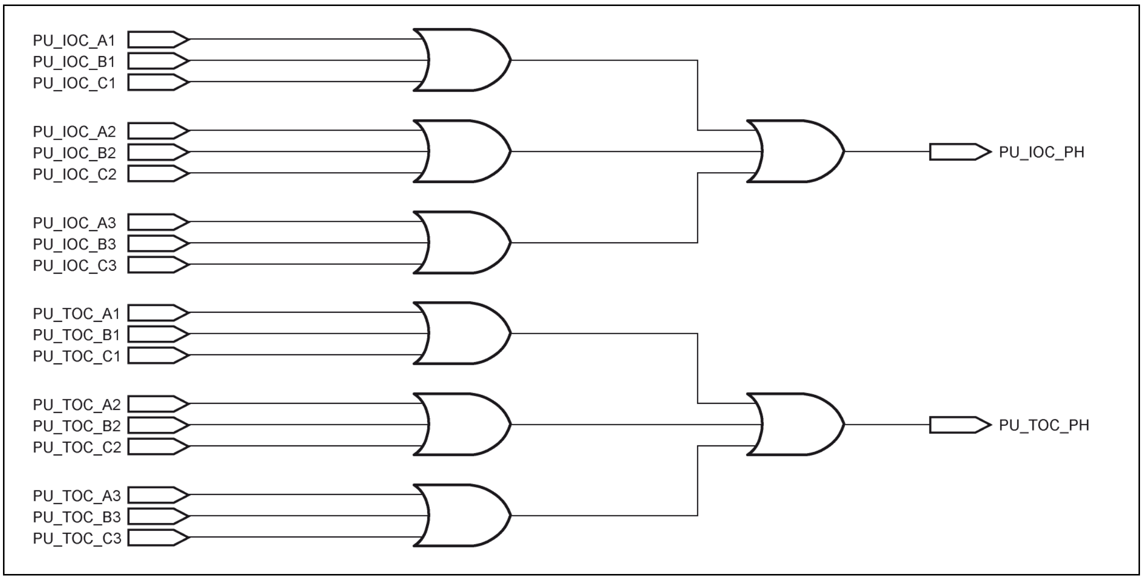


Figure 3.14.1: Activation Logic of Phase Overcurrent Elements Used by the Fault Detector.

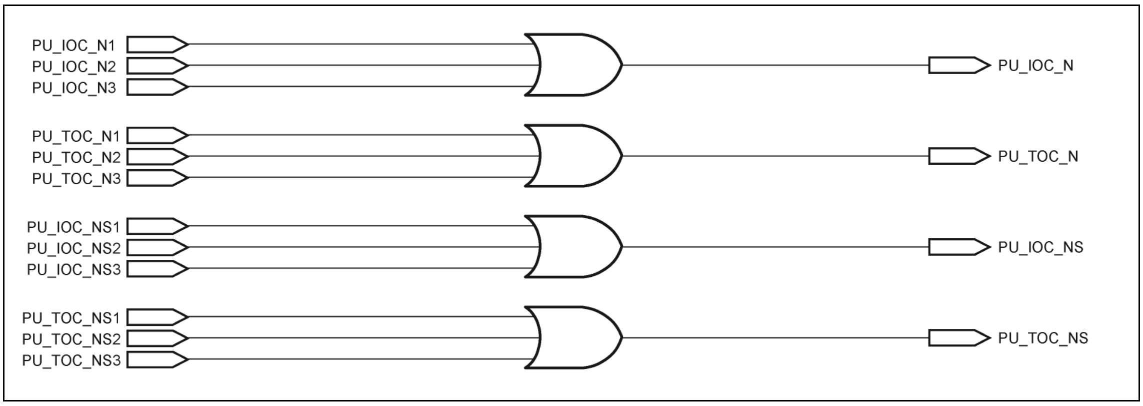


Figure 3.14.2: Activation Logic of Ground and Negative Sequence Overcurrent Elements Used by the Fault Detector.

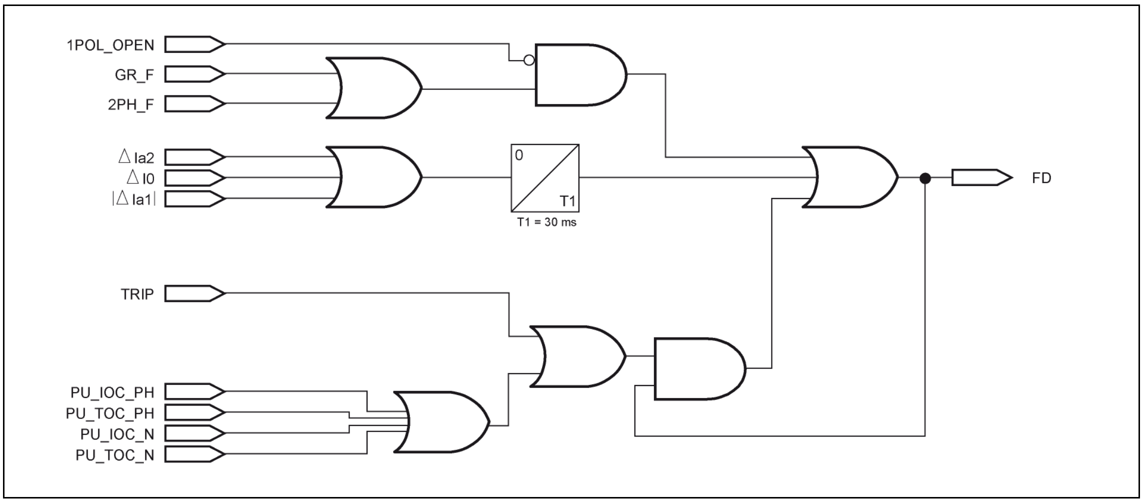


Figure 3.14.3: Fault Detector Block Diagram.

3.14.2 Digital Inputs and Events of the Fault Detector

The fault detector does not present any digital input, not even enable, remaining always in operation.

3.14.3 Digital Outputs and Events of the Fault Detector

Table 3.14-1: Digital Outputs and Events of the Fault Detector		
Name	**Description**	**Function**
FD	Fault detector activated	Detection of the existence of a fault.

3.15 Overexcitation Protection Unit

3.15.1 Operating Principles

The effective value of the input phase voltage measured through **VA** channel and the frequency of the signal are calculated. These values are plotted on a voltage/frequency comparison curve where it is determined if the average values exceed the value set ratio value.

The ratio between the adjusted nominal voltage and adjusted nominal frequency is taken as the unit value (V/Hz=1). The function's pickup setting depends on this unit value. The function is activated when the ratio between the measured voltage and frequency exceeds this value. Note that the voltage measured can be a line-to-line or line-to-neutral voltage, while the Nominal Voltage setting is a value between phases; consequently, if line-to-neutral voltage is used, the V/Hz ratio should be multiplied by √3.

The pickup of the unit takes place when the measured value of the voltage/frequency ratio exceeds the set V/Hz value by 1.05 times, resetting when the measurement drops below the set pickup value.

The same setting used for Frequency Units (**Inhibit Voltage**) is used to disable trips in this unit when the measured voltage is below a certain value.

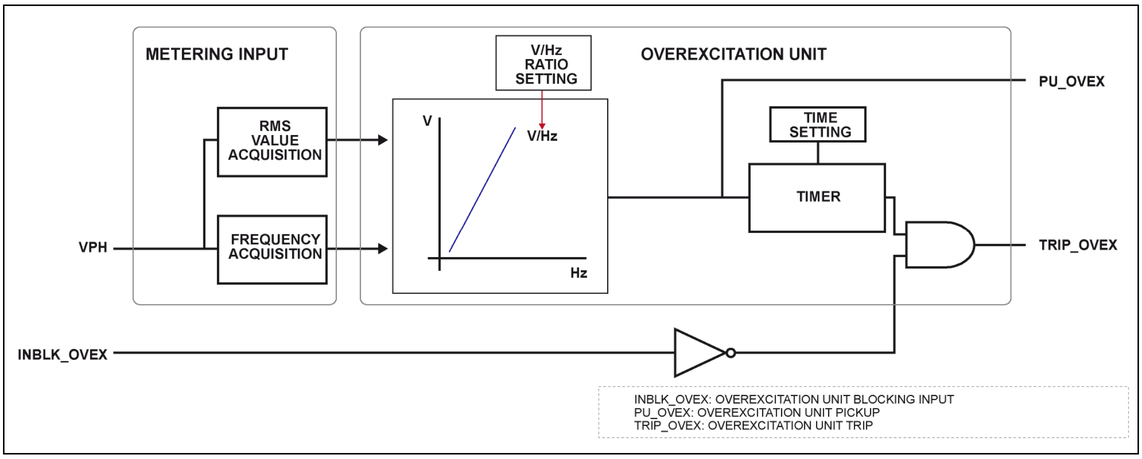


Figure 3.15.1: Overexcitation Unit Block Diagram.

Pickup activation enables the timing function to determine the performance of the time element. The activation of the output requires the pickup to remain activated throughout the entire time elapse set in the timer. The resetting of the pickup signal means that the output timer will start counting from zero when pickup conditions are present once again. The user can choose between **Fixed Time** and **Inverse Curve** timing types. The equation for the **Inverse Curve** is as follows:

$$t = 0.8 + \frac{2 \cdot Overex.Dial}{\left(\frac{V/f}{(V_N/f_N)\ setting} - 1 \right)^2}$$

where V and f are the measured voltage between phases and the measured frequency.

3.15.2 Application Description

The purpose of an overexcitation protection is to protect the machine against overvoltage and underfrequency situations. Based on the equation that defines the voltage induced in a coil: $E = 4.44 \cdot f \cdot A \cdot N \cdot B_{MAX}$; the "maximum flow" (B_{MAX}) fulfills the following expression:

$$B_{MAX} = K \cdot \frac{E}{f}$$

and, therefore, the magnetic flow in the machine's core is directly proportional to the voltage and inversely proportional to the frequency.

The measurement of the V/Hz ratio is an indicator of the existing excitation. The magnetic core is saturated when this V/Hz ratio exceeds a permissible value, which gives rise to increased voltage between the strips that form the core, causing damage to the iron. When this happens, the magnetic path for which the machine was designed cannot accommodate the increased flow, thus generating "leakage currents" that cause thermal damage.

Under normal conditions, the voltage regulators of generators and other power system control elements maintain voltage within proper margins. However, anomalous conditions like those described below can occur:

- **Overvoltages**: When starting or stopping generators, with load losses in "island" configurations or load shedding. In addition, if the control system is not functioning properly, overvoltage situations can extend themselves over time.
- **Underfrequency**: For isolated or poorly meshed systems under overload conditions and for malfunction operations in load shedding schemes.

6IRV-A has one overexcitation element whereas **6IRV-B** has four.

3.15.3 Overexcitation Protection Unit Settings

Overexcitation Protection Unit Settings			
Setting	**Range**	**Step**	**By Default**
Overexcitation Enable	YES / NO		NO
Overexcitation Pickup	1 - 3 V/Hz	0.1 V/Hz	1.1
Overexcitation Curve	0: Definite Time 1: Inverse		0: Definite Time
Overexcitation Dial	0.01 - 10	0.1	1
Overexcitation Delay	0.00 - 600 s	0.01 s	1 s

- **Overexcitation Protection Unit: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - ACTIVATE GROUP	0 - GENERAL	…
2 - CHANGE SETTINGS	**1 - PROTECTION**	**10 - OVEREXCITATION**
3 - INFORMATION	….	…

6IRV-A MODELS

0 - FUSE FAILURE	**0 - OVEREX. ENABLE**
…	**1 - OVEREX. PICKUP**
10 - OVEREXCITATION	**2 - OVEREX. CURVE**
…	**3 - OVEREX. DIAL**
	4 - OVEREX. DELAY

6IRV-B MODELS

0 - FUSE FAILURE	**0 - UNIT 1**	**0 - OVEREX. ENABLE**
…	**1 - UNIT 2**	**1 - OVEREX. PICKUP**
10 - OVEREXCITATION	**2 - UNIT 3**	**2 - OVEREX. CURVE**
…	**3 - UNIT 4**	**3 - OVEREX. DIAL**
		4 - OVEREX. DELAY

3.15.4 Digital Inputs of the Overexcitation Module

Table 3.15-1: Digital Inputs of the Overexcitation Module

Name	Description	Function
INBLK_OVEX	Overexcitation unit blocking input (6IRV-A)	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.
ENBL_OVEX	Overexcitation unit enable input (6IRV-A)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
INBLK_OVEX1	Overexcitation unit 1 blocking input (6IRV-B)	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.
INBLK_OVEX2	Overexcitation unit 2 blocking input (6IRV-B)	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.

Table 3.15-1: Digital Inputs of the Overexcitation Module		
Name	**Description**	**Function**
INBLK_OVEX3	Overexcitation unit 3 blocking input (6IRV-B)	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.
INBLK_OVEX4	Overexcitation unit 4 blocking input (6IRV-B)	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.
ENBL_OVEX1	Overexcitation unit 1 enable input (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_OVEX2	Overexcitation unit 2 enable input (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_OVEX3	Overexcitation unit 3 enable input (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_OVEX4	Overexcitation unit 4 enable input (6IRV-B)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

3.15.5 Auxiliary Outputs and Events of the Overexcitation Module

Table 3.15-2: Auxiliary Outputs and Events of the Overexcitation Module

Name	Description	Function
PU_OVEX	Overexcitation unit pickup (6IRV-A)	Unit pickup and timing start.
PU_OVEX1	Overexcitation unit 1 pickup (6IRV-B)	Unit pickup and timing start.
PU_OVEX2	Overexcitation unit 2 pickup (6IRV-B)	Unit pickup and timing start.
PU_OVEX3	Overexcitation unit 3 pickup (6IRV-B)	Unit pickup and timing start.
PU_OVEX4	Overexcitation unit 4 pickup (6IRV-B)	Unit pickup and timing start.
TRIP_OVEX	Overexcitation unit trip (6IRV-A)	Trip of the unit.
TRIP_OVEX1	Overexcitation unit 1 trip (6IRV-B)	Trip of the unit.
TRIP_OVEX2	Overexcitation unit 2 trip (6IRV-B)	Trip of the unit.
TRIP_OVEX3	Overexcitation unit 3 trip (6IRV-B)	Trip of the unit.
TRIP_OVEX4	Overexcitation unit 4 trip (6IRV-B)	Trip of the unit.
OVEX_ENBLD	Overexcitation unit enabled (6IRV-A)	Indication of enabled or disabled status of the unit.
OVEX_ENBLD1	Overexcitation unit 1 enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
OVEX_ENBLD2	Overexcitation unit 2 enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
OVEX_ENBLD3	Overexcitation unit 3 enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
OVEX_ENBLD4	Overexcitation unit 4 enabled (6IRV-B)	Indication of enabled or disabled status of the unit.
INBLK_OVEX	Overexcitation unit blocking input (6IRV-A)	The same as for the Digital Inputs.
INBLK_OVEX1	Overexcitation unit 1 blocking input (6IRV-B)	The same as for the Digital Inputs.
INBLK_OVEX2	Overexcitation unit 2 blocking input (6IRV-B)	The same as for the Digital Inputs.
INBLK_OVEX3	Overexcitation unit 3 blocking input (6IRV-B)	The same as for the Digital Inputs.
INBLK_OVEX4	Overexcitation unit 4 blocking input (6IRV-B)	The same as for the Digital Inputs.
ENBL_OVEX	Overexcitation unit enable input (6IRV-A)	The same as for the Digital Inputs.
ENBL_OVEX1	Overexcitation unit 1 enable input (6IRV-B)	The same as for the Digital Inputs.
ENBL_OVEX2	Overexcitation unit 2 enable input (6IRV-B)	The same as for the Digital Inputs.
ENBL_OVEX3	Overexcitation unit 3 enable input (6IRV-B)	The same as for the Digital Inputs.
ENBL_OVEX4	Overexcitation unit 4 enable input (6IRV-B)	The same as for the Digital Inputs.

3.15.6 Overexcitation Unit Test

Set the transformer Overexcitation Unit (V/Hz) to 1.0 V/Hz, trip time to 5 seconds, the nominal values being 110Vac and 50Hz and the voltage type U_{AB}.

Apply 30V at 50Hz through the phase voltage channel for 300ms (as 10 complete voltage cycles are initially needed for frequency calculation) being Inhibit Voltage value below 30V (for example 5V).

Apply 110Vac at 50.00Hz through the phase voltage channel for 300ms and check that the unit is activated.

After unplugging the test voltage check that time recorder is within the range 4.85 - 5.25 s.

3.16 Stub Bus Protection

3.16.1 Operating Principles

The stub bus protection is normally used in breaker and a half or ring configurations and is intended for protecting the section between the two current transformers and the line sectionalizing switch (referred to as stub bus) when the latter is open. In this case, if the voltage transformer is on the line side, some elements will not be able to trip since they have not sufficient voltage to be polarised. This function is only provided in **6IRV-B** relays.

When the line sectionalizing switch is open, if a fault occurs outside the bus stub, there is practically zero current to the relay, (since the same current flows through both transformer secondary windings but in opposite directions).

However, in case the fault is located on the stub bus, the currents through the secondary windings of both transformers add up, and there is a fault current to the relay.

Figure 3.16.1 shows a breaker and a half substation with a fault on the stub bus of bay **L1**, protected by a **6IRV-B** relay.

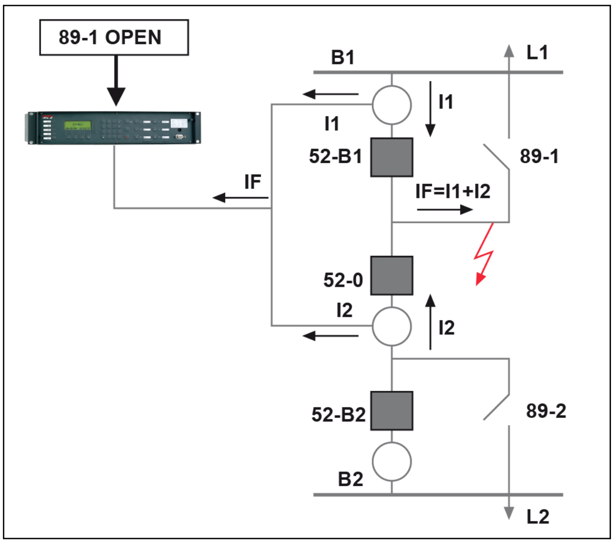


Figure 3.16.1: Breaker-and-a-Half Substation with Stub Bus Fault.

The Stub Bus protection operates only with the aperture of the line sectionalizer (activation of the **Open Line Sectionalizer** (**IN_89L_A**) input, to which the normally closed contact of the line sectionalizer position should be wired) and this involves a non-directional overcurrent element with a defined time.

Stub Bus protection pickup is normally set at a high level, to prevent trips on external faults that cause saturation of any CT (thus leading to a differential current).

Figure 3.16.2 represents the operation diagram of stub bus protection.

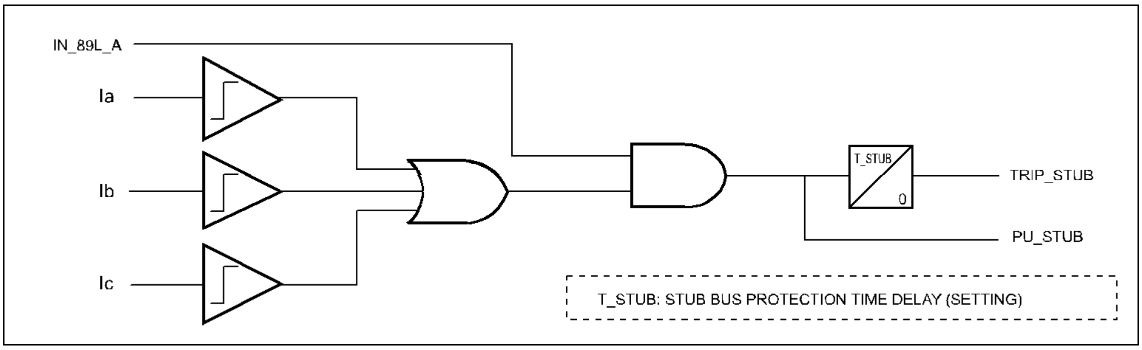


Figure 3.16.2: Block Diagram of the Stub Bus Protection.

The Stub Bus protection operates when the phase current equals 1.05 times the pickup value and resets when said current equals the pickup value.

3.16.2 6IRV-B Relay Stub Bus Protection

6IRV-B relays are designed for the protection of a dual breaker bay and measure the currents from the two CTs associated to said bay (I1 and I2 in figure 3.16.1). The line current **I** is calculated internally by the sum of I1 and I2. The saturation of a CT on a fault external to the Stub Bus generates a line current that can operate the Stub Bus protection.

In order to increase the stability of said protection on external faults, the **6IRV-B** relay Stub Bus protection incorporates a percent restraint characteristic with adjustable slope. Figure 3.16.3 shows the characteristic associated to phase A. The straight line of adjustable slope, α, goes through the origin. The IAMIN current is the element pìckup setting. A similar characteristic applies to phases B and C.

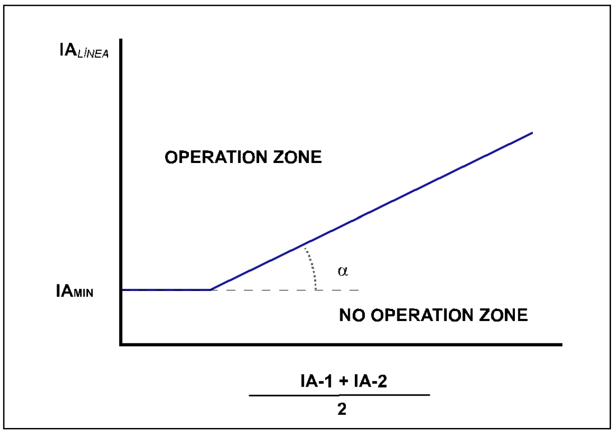


Figure 3.16.3: Operating Characteristic of 6IRV-B Relay Stub Bus Protection.

Phase A restraint current is calculated as $IA_{rest} = \frac{IA-1+IA-2}{2}$, where IA-1 and IA-2 are currents measured by relay channels IA-1 and IA-2.

3.16.3 Stub Bus Protection Settings

Stub Bus			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.02 - 30) In A	0.01 A	2 In
Time delay	0 - 100 s	0.01 s	0 s
Restraint slope	0 200%	1%	20%

- **Stub Bus: HMI access**

6IRV-B MODELS

0 - CONFIGURATION		0 – FUSE FAILURE
1 - OPERATIONS		…
2 - CHANGE SETTINGS	0 - GENERAL	**11 - STUB BUS PROTECTION**
3 - INFORMATION	**1 - PROTECTION**	…
	…	

0 - FUSE FAILURE	**0 - STUB BUS PROT. ENA**
…	**1 - STUB BUS PROT. PU**
11 - STUB BUS PROTECTION	**2 - STUB BUS PROT. DLY.**
…	**3 - RESTRAINT SLOPE**

3.16.4 Digital Inputs and Events of the Stub Bus Protection

Table 3.16-1:Digital Inputs and Events of the Stub Bus Protection		
Name	**Description**	**Function**
ENBL_STUB	Stub Bus protection enable input	Activation of this input puts the element into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
IN_89L_A	Open line sectionalizer input	Activation of this input indicates that the normally closed contact of the line sectionalizer is closed.

3.16.5 Digital Outputs and Events of the Stub Bus Protection

Table 3.16-2: Digital Outputs and Events of the Stub Bus Protection		
Name	**Description**	**Function**
PU_STUB	Stub Bus protection pickup	Pickup of the unit
TRIP_STUB	Stub Bus protection trip	Trip of the unit
STUB_ENBLD	Stub Bus protection enabled	Indication of enabled or disabled status of the unit.
ENBL_STUB	Stub Bus protection enable input	The same as for the Digital Input.
IN_89L_A	Open line sectionalizer input	The same as for the Digital Input.

3.16.6 Stub Bus Protection Element Test

The Stub Bus protection will be enabled and the remaining elements disabled.

The following indicators will be monitored during the test: In the display on the **Information** - **Status** - **Measuring Elements** - **Stub Bus Protection** screen, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Stub Bus Protection**).

- **6IRV-B Models**

The percentage characteristic of the **6IRV-B** relay STUB bus protection is tested phase by phase, setting a restraint current and increasing the current until the element pickup value is determined. For testing, it is recommended to inject currents **I**-1 and **I**-2 in opposite phase (180º phase angle difference). The restraint current will be equal to the sum of the magnitudes of both currents divided by 2, whereas line current will be equal to the difference of the two magnitudes.

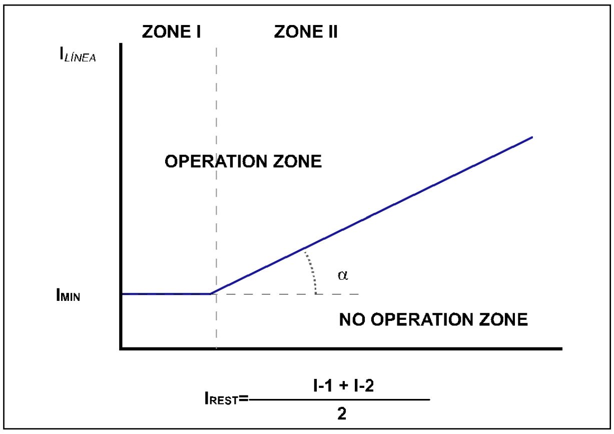


Figure 3.16.4:Graphic for the STUB bus Protection Percentage Characteristic. (6IRV-B Models).

The difference of the two magnitudes can be increased, while keeping constant the sum of the two magnitudes, until the STUB bus protection picks up.

The following table shows the values of currents **I**-1 and **I**-2 that make the STUB Bus protection to pickup, for the following settings: pickup (IMIN)=1 A, slope (α)=20%. Said table is obtained by solving the following system of equations:

$\frac{\lvert I-1\rvert+\lvert I-2\rvert}{2}=I_{RESTRAINT}$	$\lvert I-1\rvert-\lvert I-2\rvert=I_{LINE}$

ZONE I

IRESTRAINT / **ILINE**	**0.525 A**	**1 A**	**3 A**	**5 A**
1*1.05 A	I-1=1.05 0º I-2=0 0º	I-1=1.525 0º I-2=0.475 180º	I-1=3.525 0º I-2=2.475 180º	I-1=5.525 0º I-2=4.475 180º

ZONE II

IRESTRAINT / **ILINE**	**6 A**	**7 A**	**8 A**	**9 A**
1.2*1.05 A	I-1=6.63 0º I-2=5.37 0º			
1.4*1.05 A		I-1=7.73 0º I-2=6.26 180º		
1.6*1.05 A			I-1=8.84 0º I-2=7.16 180º	
1.8*1.05 A				I-1=9.94 0º I-2=8.05 180º

3.17 Current Measurement Supervision

3.17.1 Introduction

Models **6IRV** count on a supervision system for the set of elements that make up the phase current measurement system, from external current transformers, to copper cables that connect them to the relay, up to the internal magnetic modules on the **6IRV** relay itself.

3.17.2 Operation Principles

This supervision function is exclusively based on the measurement of phase currents. Measurement of the three phase currents is required for its application, otherwise it must be disabled.

Due to the unlikely simultaneous failure of more than one phase, a simple algorithm is used to enable the detection of failures in a single phase each time. Simultaneous failures are not detected.

When a phase current (phase **X**) below 2% of its rated value is detected, other phase currents are checked (phases **Y** and **Z**) to see if they exceed 5% and are below 120% of their rated value. The angular difference between these currents is also calculated, which, under normal operating conditions, must be within the 120º±10º range.

If "normal" operating conditions are detected in phases **Y** and **Z**, the phase **X** current circuit failure alarm is activated.

Figure 3.17.1 shows the supervision algorithm used for current measurement in phase A.

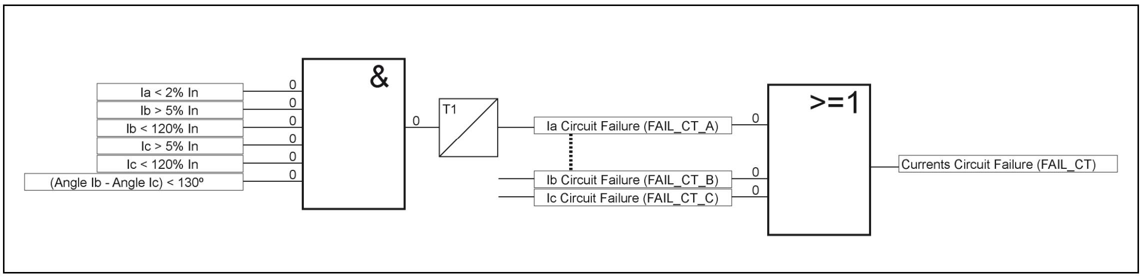


Figure 3.17.1:Supervision Algorithm for Current Measurement in Phase A.

Failure detection in any of the measuring circuits only generates the activation of the following signals: **FAIL_CT_A**, **FAIL_CT_B**, **FAIL_CT_C** and **FAIL_CT**. Blocking the operation of protection elements that are affected by measurement unbalance of phase currents must be programmed in ***ZIVerComPlus***® logic.

6IRV-B models, designed for breaker and a half or ring configurations, can monitor two CTs using phase currents IX-1 (X=A, B, C) for CT-1 and IX-2 (X=A, B, C) for CT-2.

3.17.3 Current Measurement Supervision Settings

Current Measurement Supervision			
Setting	**Range**	**Step**	**By Default**
CT Supervision Enable	YES / NO		NO
CT Supervision Time	0.15 - 300 s		0.5 s

- **Current Measurement Supervision: HMI Access**

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**7 - CT SUPERVISION**
3 - INFORMATION	...	...

6IRV-A MODELS

0 - FUSE FAILURE	
...	**0 - CT SUPERV ENABLE**
7 - CT SUPERVISION	**1 - CT SUPERV TIME**
...	

6IRV-B MODELS

0 - FUSE FAILURE		
...	**0 - BREAKER 1**	**0 - CT SUPERV ENABLE**
7 - CT SUPERVISION	**1 - BREAKER 2**	**1 - CT SUPERV TIME**
...		

3.17.4 Digital Inputs and Events of Current Measurement Supervision Module

Table 3.17-1:Digital Inputs and Events of the Current Measurement Supervision Module

Name	Description	Function
IN_ENBL_SUPCT	CT Supervision enable input (6IRV-A)	Activation of this input brings the element into operation. It can be assigned to a digital input by level or to a command from the communications protocol or from the HMI: The default value for this logic input is “1”.
IN_ENBL_SUPCT1	CT 1 Supervision enable input (6IRV-B)	
IN_ENBL_SUPCT2	CT 2 Supervision enable input (6IRV-B)	
IN_BLK_SUPCT	CT Supervision block input (6IRV-A)	Activation of this input generates the blocking of the supervision.
IN_BLK_SUPCT1	CT 1 Supervision block input (6IRV-B)	
IN_BLK_SUPCT2	CT 2 Supervision block input (6IRV-B)	

3.17.5 Auxiliary Outputs and Events of the Current Measurement Supervision Module

Table 3.17-2:Auxiliary Outputs and Events of the Current Measurement Supervision Module

<table>
<tr><th>Name</th><th>Description</th><th>Function</th></tr>
<tr><td>FAIL_CT_A</td><td>Activation of CT Supervision Element for Phase A (6IRV-A)</td><td rowspan="12">Its activation indicates the existence of a failure in the measuring system of one of the phases.</td></tr>
<tr><td>FAIL_CT_B</td><td>Activation of CT Supervision Element for Phase B (6IRV-A)</td></tr>
<tr><td>FAIL_CT_C</td><td>Activation of CT Supervision Element for Phase C (6IRV-A)</td></tr>
<tr><td>FAIL_CT</td><td>Activation of CT Supervision Element (6IRV-A)</td></tr>
<tr><td>FAIL_CT_A1</td><td>Activation of CT 1 Supervision Element for Phase A (6IRV-B)</td></tr>
<tr><td>FAIL_CT_B1</td><td>Activation of CT 1 Supervision Element for Phase B (6IRV-B)</td></tr>
<tr><td>FAIL_CT_C1</td><td>Activation of CT 1 Supervision Element for Phase C (6IRV-B)</td></tr>
<tr><td>FAIL_CT1</td><td>Activation of CT 1 Supervision Element (6IRV-B)</td></tr>
<tr><td>FAIL_CT_A2</td><td>Activation of CT 2 Supervision Element for Phase A (6IRV-B)</td></tr>
<tr><td>FAIL_CT_B2</td><td>Activation of CT 2 Supervision Element for Phase B (6IRV-B)</td></tr>
<tr><td>FAIL_CT_C2</td><td>Activation of CT 2 Supervision Element for Phase C (6IRV-B)</td></tr>
<tr><td>FAIL_CT2</td><td>Activation of CT 2 Supervision Element (6IRV-B)</td></tr>
<tr><td>ENBL_SUPCT</td><td>Activation of CT Supervision enabled (6IRV-A)</td><td rowspan="3">Block output due to condition of fuse failure detected by the element in question.</td></tr>
<tr><td>ENBL_SUPCT1</td><td>Activation of CT 1 Supervision enabled (6IRV-B)</td></tr>
<tr><td>ENBL_SUPCT2</td><td>Activation of CT 2 Supervision enabled (6IRV-B)</td></tr>
<tr><td>EB_SUPCT</td><td>Activation of CT Supervision block Input</td><td rowspan="3">Block output due to condition of fuse failure (either detected by the element itself, or else by digital input).</td></tr>
<tr><td>EB_SUPCT1</td><td>Activation of CT 1 Supervision block Input (6IRV-B)</td></tr>
<tr><td>EB_SUPCT2</td><td>Activation of CT 2 Supervision block Input (6IRV-B)</td></tr>
</table>

3.18 Single / Three-Phase Tripping Logic

3.18.1 Trip Logic

6IRV terminal units are provided with a single- or three-phase Tripping Logic. Trip commands are generated for phase A, B, and C according to activation of protection elements, blocking status contact inputs, element masks, recloser status, etc. The Tripping Logic comprises the following sub-logics:

1. **Trip Command Generation Logic**, in charge of processing the activation of the different protection elements responsible for trips to generate a general trip command.
2. **Phase Trip Logic**, in charge of generating independent tripping signals for phases A, B, and C (outputs **TRIP_A**, **TRIP_B** and **TRIP_C**), which will be used by the command module (see 3.19) to generate the open outputs of each pole.

The block diagram of Figure 3.18.7 shows the complete Single / Three-Phase Tripping Logic.

3.18.2 Trip Command Generation Logic

This logic generates a trip command according to activation of the protection elements. The settings to enable or the elements involved are (depending on model):

Auxiliary Units:
Phase Instantaneous Overcurrent Elements.
Ground Instantaneous Overcurrent Elements.
Negative Sequence Instantaneous Overcurrent Elements.
Phase Time Overcurrent Elements.
Ground Time Overcurrent Elements.
Negative Sequence Time Overcurrent Elements.
Stub Bus Protection.
Thermal Image Protection.
Open Phase Detector.
Phase Undervoltage Elements.
Phase Overvoltage Elements.
Ground Overvoltage Elements.
Underfrequency Elements.
Overfrequency Elements.
Rate Of Change Elements.
Overexcitation Units.
Pole Discordance Detectors.
External Trip.

Trips by auxiliary units can be independently enabled or disabled in the **Auxiliary Units Mask** setting. Setting any of these elements to **0** (disabled) will disable the element from tripping.

CAUTION!

Given that the setting of the Auxiliary Unit Mask allows to inhibit the trip by the auxiliary units, if it is required that any of these produce a trip, it should be ensured that this setting has an unmasked measuring unit. Otherwise, the protection will be unable to trip units.

As shown in Figure 3.18.7 the Trip Command will be generated if any of the following occurs:

1. A trip of any of the auxiliary units.
2. The activation of the input **Three-Phase External Trip (IN_EXT_3PH)** or the inputs **Pole A External Trip (IN_EXT_A)**, **Pole B External Trip B (IN_EXT_B)** and **Pole C External Trip (IN_EXT_C)**.
3. The prior existence of a trip.

In addition, the **Trip Blocking** (**INBLK_TRIP**) digital input should not be activated and the **Fault Detector** (**FD**) should be activated, provided the trip does not originate from Voltage, Frequency, Thermal Image, Pole Discordance, Overexcitation or **External Three-Phase Trip** input **(IN_EXT_3PH)**.

3.18.3 Trip Logic Operation

3.18.3.a Phase Trip Logic

The phase trip logic function generates the independent trip command for each of the phases (signals **TRIP_A**, **TRIP_B** and **TRIP_C**), the **Trip** signal (**TRIP**) and the **Three-Phase Trip** signal (**TRIP_3PH**). To generate these signals, the logic uses the **Trip Command** signal and the **Three-Phase Trip Ready** signal (**3PH_PREP**), described in the previous sections.

The tripping logic of the poles is formed of three single-phase sub-logics corresponding to phases A, B and C. The trip command is common to the three logics. Pole trips can be disabled by means of **INBLK_TRIP_A**, **INBLK_TRIP_B**, **INBLK_TRIP_C** inputs.

It is worth noting that external trip inputs per pole **(IN_EXT_A, IN_EXT_B** and **IN_EXT_C)** do not depend on any intermediate logic. Their operation translates into tripping only the pole involved, regardless of the status of the signals **INBLK_TRIP_A**, **INBLK_TRIP_B**, **INBLK_TRIP_C.**

Once the trip generating signals are deactivated, the trip contacts remain latched until:

1. The current in the tripped phase is zero (for single-phase trips), and
2. The Fault Detector is deactivated or the logic input signal **Trip Blocking** (**INBLK_TRIP**) is activated, and
3. the applicable pole trip block input is activated.

When the trip is produced by one of the external trip inputs per pole **(IN_EXT_A, IN_EXT_B** and **IN_EXT_C)**, it will be released when the corresponding input is deactivated.

3.18.3.b Tripping Logic of the Breaker

The function of this logic is to generate the direct trip (**TRIP**) output.

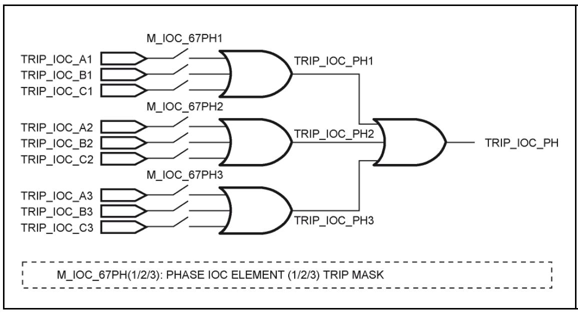


Figure 3.18.1: Activation Logic of Phase Instantaneous Overcurrent Units for Tripping Logic.

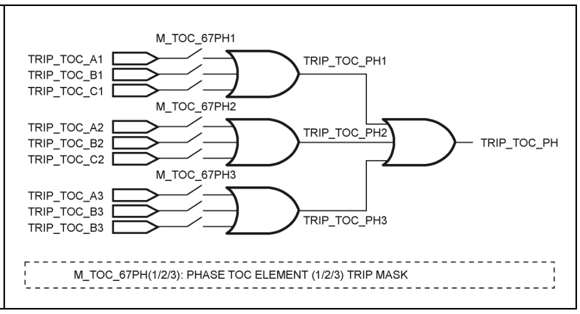


Figure 3.18.2: Activation Logic of Phase Time Overcurrent Units for Tripping Logic.

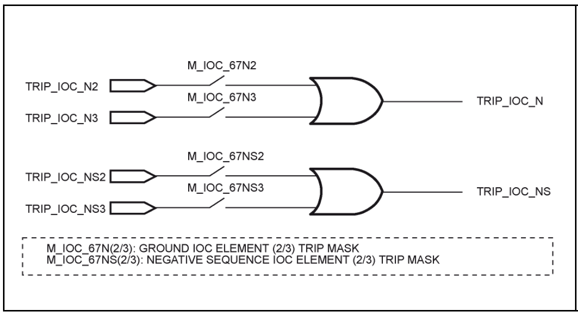


Figure 3.18.3: Activation Logic of Ground and Negative Sequence Instantaneous Overcurrent Units for Tripping Logic.

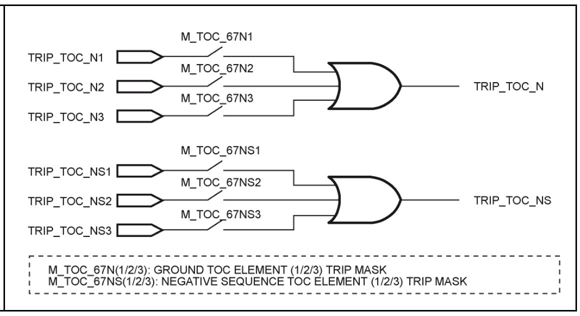


Figure 3.18.4: Activation Logic of Ground and Negative Sequence Time Overcurrent Units for Tripping Logic.

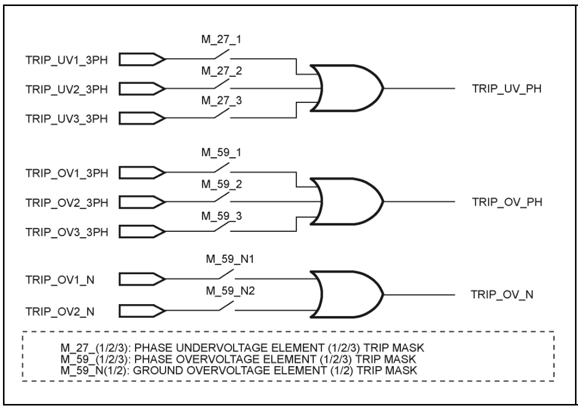


Figure 3.18.5: Activation Logic of Voltage Units for Tripping Logic.

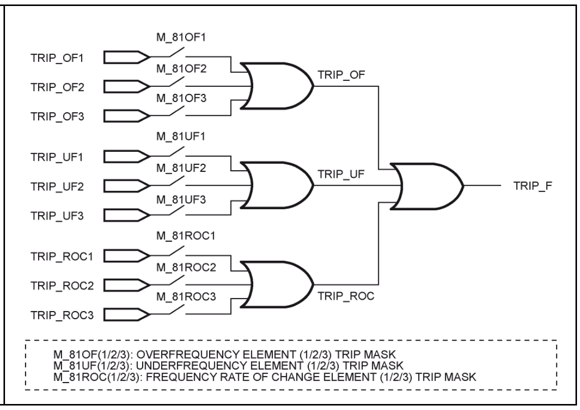


Figure 3.18.6: Activation Logic of Frequency Units for Tripping Logic.

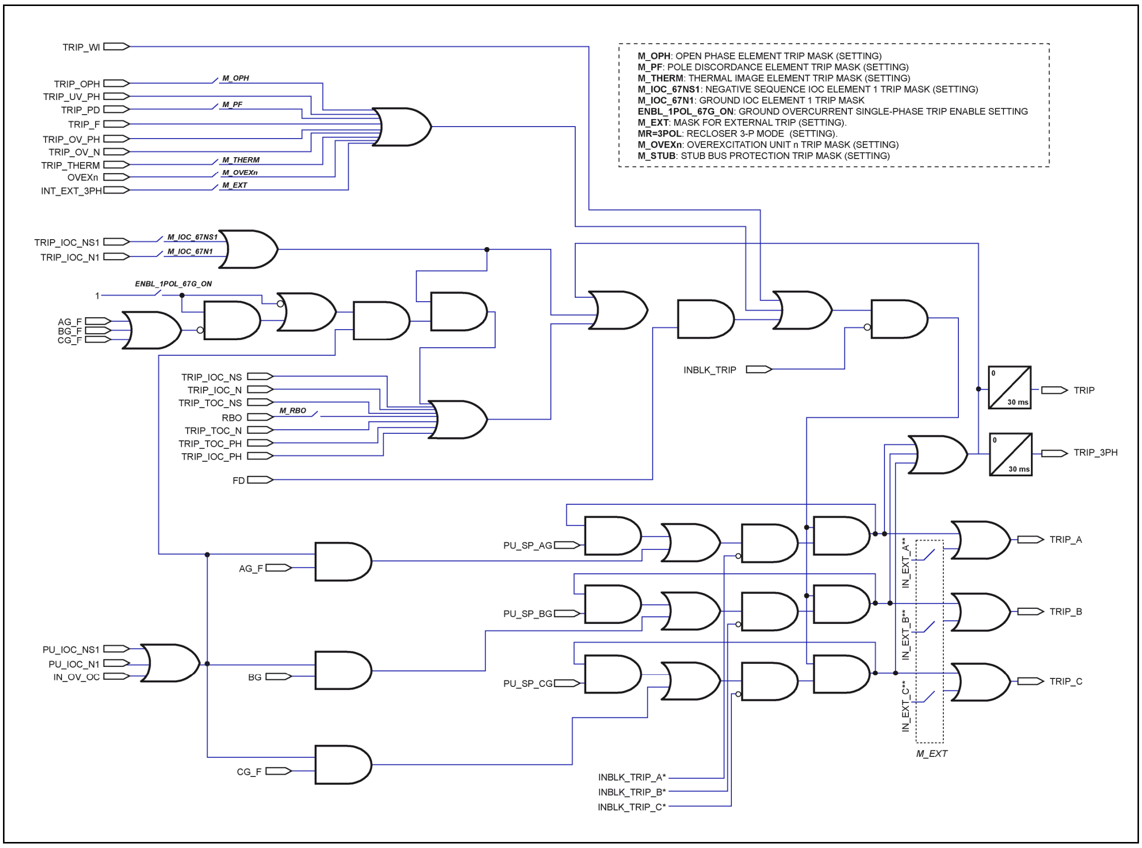


Figure 3.18.7: Block Diagram of the Single-Three-Phase Trip Logic.

In **6IRV-B** relays:

- Signal **TRIP_PD** will be an OR of **TRIP_PD1** and **TRIP_PD2** signals.
- Signal **RECLOSING** will be an OR of the signals **RECLOSING1** and **RECLOSING2**.
- Signal **RCLS_LO** will follow the logic included in figure 3.18.8.
- Signal **BMO** will follow the logic included in figure 3.18.9.

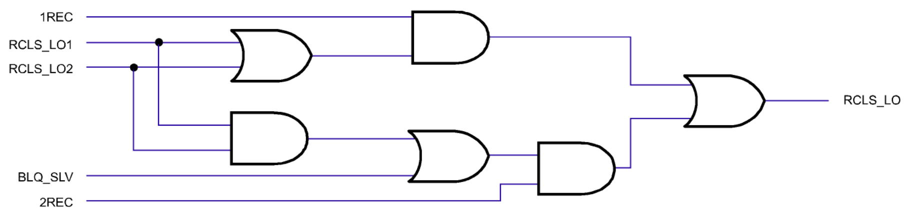


Figure 3.18.8: Logic of Recloser Internal Block Signal Generation (6IRV-B).

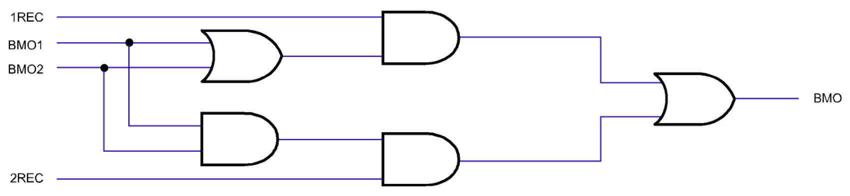


Figure 3.18.9: Logic of Recloser Command Block Signal Generation (6IRV-B).

3.18.4 Tripping Logic Settings

Tripping Logic			
Setting	**In Display**	**Range**	**By default**
Auxiliary Units Activation Mask			
Thermal image	THERMAL IMG	YES / NO	NO
Overexcitation (6IRV-A)	OVEX	YES / NO	NO
Overexcitation 1 (6IRV-B)	OVEX1	YES / NO	NO
Overexcitation 2 (6IRV-B)	OVEX2	YES / NO	NO
Overexcitation 3 (6IRV-B)	OVEX3	YES / NO	NO
Overexcitation 4 (6IRV-B)	OVEX4	YES / NO	NO
Open phase	OPEN PHASE	YES / NO	NO
Pole discordance detector (6IRV-A)	POLE DISCREP	YES / NO	NO
Pole discordance detector breaker 1 (6IRV-B)	POLE DISCREP1	YES / NO	NO
Pole discordance detector breaker 2 (6IRV-B)	POLE DISCREP2	YES / NO	NO
Phase time overcurrent (51-1)	TOC PH1	YES / NO	NO
Phase time overcurrent (51-2)	TOC PH2	YES / NO	NO
Phase time overcurrent (51-3)	TOC PH3	YES / NO	NO
Phase instantaneous overcurrent (50-1)	IOC PH1	YES / NO	NO
Phase instantaneous overcurrent (50-2)	IOC PH2	YES / NO	NO
Phase instantaneous overcurrent (50-3)	IOC PH3	YES / NO	NO
Ground time overcurrent (51N-1)	TOC GND1	YES / NO	NO
Ground time overcurrent (51N-2)	TOC GND2	YES / NO	NO
Ground time overcurrent (51N-3)	TOC GND3	YES / NO	NO
Ground instantaneous overcurrent (50N-1)	IOC GND1	YES / NO	NO
Ground instantaneous overcurrent (50N-2)	IOC GND2	YES / NO	NO
Ground instantaneous overcurrent (50N-3)	IOC GND3	YES / NO	NO
Negative Sequence time overcurrent (51Q-1)	TOC NEG SEQ1	YES / NO	NO
Negative Sequence time overcurrent (51Q-2)	TOC NEG SEQ2	YES / NO	NO
Negative Sequence time overcurrent (51Q-3)	TOC NEG SEQ3	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-1)	IOC NEG SEQ1	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-2)	IOC NEG SEQ2	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-3)	IOC NEG SEQ3	YES / NO	NO
Stub Bus Protection (6IRV-B)	STUB BUS	YES / NO	NO
Phase undervoltage (27-1)	UNDERVOLT PH1	YES / NO	NO
Phase undervoltage (27-2)	UNDERVOLT PH2	YES / NO	NO
Phase undervoltage (27-3)	UNDERVOLT PH3	YES / NO	NO
Phase overvoltage (59-1)	OVERVOLT PH1	YES / NO	NO
Phase overvoltage (59-2)	OVERVOLT PH2	YES / NO	NO
Phase overvoltage (59-3)	OVERVOLT PH3	YES / NO	NO
Ground overvoltage (59N-1)	OVERVOLT G1	YES / NO	NO
Ground overvoltage (59N-2)	OVERVOLT G2	YES / NO	NO
Underfrequency (81m-1)	UNDFREQ1	YES / NO	NO
Underfrequency (81m-2)	UNDFREQ2	YES / NO	NO
Underfrequency (81m-3)	UNDFREQ3	YES / NO	NO
Overfrequency (81M-1)	OVERFREQ1	YES / NO	NO
Overfrequency (81M-2)	OVERFREQ2	YES / NO	NO
Overfrequency (81M-3)	OVERFREQ3	YES / NO	NO
Rate of Change (81D-1)	ROC FREQ1	YES / NO	NO
Rate of Change (81D-2)	ROC FREQ2	YES / NO	NO
Rate of Change (81D-3)	ROC FREQ3	YES / NO	NO
External Trip (DISP EXT)	DISP EXT	YES / NO	NO

- **Tripping Logic: HMI Access**

MOD. 6IRV-A

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**14 - PROTECTION LOGIC**
3 - INFORMATION	...	...

0 - FUSE FAILURE	
...	
14 - PROTECTION LOGIC	**0 - AUX UNITS MASK**
...	

MOD. 6IRV-B

0 - CONFIGURATION		0 - FUSE FAILURE
1 - OPERATIONS	0 - GENERAL	...
2 - CHANGE SETTINGS	**1 - PROTECTION**	**15 - PROTECTION LOGIC**
3 - INFORMATION	...	...

0 - FUSE FAILURE	
...	
15 - PROTECTION LOGIC	**0 - AUX UNITS MASK**
...	

3.18.5 Digital Inputs and Events of the Tripping Logic

Table 3.18-1: Digital Inputs and Events of the Tripping Logic

Name	Description	Function
INBLK_TRIP	Trip Blocking Input	Activation of this input produces a block of any trip.
INPROGTRIP	Programmable Trip Input	Activating this input causes a direct three-phase trip.
INBLK_TRIP_A	Pole A Trip Block Input	Activating this input disables pole A tripping.
INBLK_TRIP_B	Pole B Trip Block Input	Activating this input disables pole B tripping.
INBLK_TRIP_C	Pole C Trip Block Input	Activating this input disables pole C tripping.
IN_EXT_A	Pole A external trip input	The activation of this input indicates the existence of a trip of the A pole of the breaker caused by an external protection.
IN_EXT_B	Pole B external trip input	The activation of this input indicates the existence of a trip of the B pole of the breaker caused by an external protection.
IN_EXT_C	Pole C external trip input	The activation of this input indicates the existence of a trip of the C pole of the breaker caused by an external protection.
IN_EXT_3PH	Three-phase external trip input	The activation of this input indicates the existence of a three-phase trip of the breaker caused by an external protection.

3.18.6 Digital Outputs and Events of the Tripping Logic

Table 3.18-2: Digital Outputs and Events of the Tripping Logic		
Name	**Description**	**Function**
TRIP_A	Pole A Trip	Trip of A pole of the breaker.
TRIP_B	Pole B Trip	Trip of B pole of the breaker.
TRIP_C	Pole C Trip	Trip of C pole of the breaker.
TRIP_3PH	Three-phase trip	Three-phase trip of the breaker.
TRIP	Trip	Trip of the breaker.
INBLK_TRIP	Trip blocking input	The same as for the Digital Input.
INPROGTRIP	Programmable Trip Input	The same as for the Digital Input.
INBLK_TRIP_A	Pole A Trip Block Input	The same as for the Digital Input.
INBLK_TRIP_B	Pole B Trip Block Input	The same as for the Digital Input.
INBLK_TRIP_C	Pole C Trip Block Input	The same as for the Digital Input.
IN_EXT_A	Pole A external trip input	The same as for the Digital Input.
IN_EXT_B	Pole B external trip input	The same as for the Digital Input.
IN_EXT_C	Pole C external trip input	The same as for the Digital Input.
IN_EXT_3PH	Three-phase external trip input	The same as for the Digital Input.

3.19 Recloser

3.19.1 Description

6IRV-A Model

6IRV-A terminal unit Recloser allows up to three reclosing attempts, with independent reclosing timers (dead time delays) for the:

- First single-phase reclosing attempt.
- First three-phase reclosing attempt.
- Second reclosing attempt (always 3-Phase).
- Third reclosing attempt (always 3-Phase).

Also, the recloser is able to operate in any of the following four modes:

1P Mode	Only single-phase reclosing is allowed. The recloser will lockout after a three-phase trip. Therefore, this mode has a single reclosing attempt, independent of the number of attempts.
3P Mode	Only three-phase reclosing is allowed, forcing the tripping logic to make all the trips of this type.
1P / 3P Mode	Both single- and three-phase reclosing is allowed. The first attempt will be either single-phase or three-phase. The remaining attempts (depending on the Reclosing Attempts setting) will always be three-phase.
Dependent Mode	Only one reclosing will be attempted after a three-phase trip. For single-phase trips, the recloser will operate according to the number of attempts selected in the Reclosing Attempts setting.

Figures 3.19.2, 3.19.3, 3.19.4, 3.19.5 and 3.19.6 show the recloser operation flow diagrams with the details for each reclosing mode. In these diagrams, the signal **RCLS** (**Recloser Start Element Activated**) corresponds to the logic output in charge of generating the trips that are allowed to be reclosed by the associated Recloser Start Masks.

6IRV-B Models

6IRV-B reclosers allow up to four reclose operations with separate reclose timer settings for:

- First single phase reclose.
- First three phase reclose.
- Second reclose (always three phase).
- Third reclose (always three phase).
- Forth reclose (always three phase).

6IRV-B relay automatic reclose function comprises two reclosers, coordinated with each other, designated **Recloser 1** and **Recloser 2**, associated to breakers 1 and 2 respectively. The **Number of reclosers** setting defines whether there are one or two reclosers in operation. When said setting is set to **Selection by DI**, the number of reclosers in operation will be defined by logic input **IN_2REC** (**Two reclosers in operation input**) state based on the following table:

IN_2REC	Result
0	1 Recloser in operation
1	2 Recloser in operation

Whenever two reclosers are in operation, reclose will take place in sequence, so that one of the reclosers must operate before the other. This recloser will be designated as master recloser whereas the other will be the slave recloser. Said selection is made through the setting **Master Recloser**. If said setting is set to **Selection by DI** the selection of the master recloser will be made by logic input **IN_1MAS** (**Master Recloser 1 input**) state based on the following table:

IN_1MAS	Result
0	Master recloser 2
1	Master recloser 1

When there is only one recloser in operation, the selection of the master recloser (through setting or digital input) allows selecting the operating recloser, as there will not be a slave recloser.

If the **Reclose Mode** setting is set to **Selection by DI**, the reclose mode will be defined by logic inputs **IN_1P** (**1P Mode Input**) and **IN_3P** (**3P Mode input**) state based on the following table:

E_1P	E_3P	Result
0	0	Dependent Mode
0	1	3P Mode
1	0	1P Mode
1	1	1P/3P Mode

Figures 3.19.7, 3.19.8, 3.19.9, 3.19.10, 3.19.11, 3.19.12, 3.19.13, 3.19.14, 3.19.15 and 3.19.16 show the flow diagrams describing the recloser operation and the features of the four reclose modes. In said figures, signal **RCLS** (**Recloser initiate**) corresponds to the output of a logic processing the reclosable trips and their reclose initiate mask settings.

3.19.2 External Trips

6IRV-A Model

The recloser operates in the same manner for trips generated by the **6IRV-A** terminal unit or by external protection. Therefore, the four modes of operation are available to reclose trips generated by other protection terminals. To take advantage of this feature, the logic input signals **External A Pole Trip** (**IN_EXT_A**), **External B Pole Trip** (**IN_EXT_B**), **External C Pole Trip** (**IN_EXT_C**) or **External Protection Trip** (**IN_EXT**) and **External Protection Three-Phase Trip** (**IN_EXT_3PH**) must be used as follows:

1. When the external device only generates three-phase trips, the recloser can operate connecting the **IN_EXT** and **IN_EXT_3PH** inputs or otherwise using only the **IN_EXT_3PH** input.
2. When the external device generates both single-phase and three-phase trips, the three **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C** inputs or otherwise the two **IN_EXT** and **IN_EXT_3PH** inputs should be connected.

6IRV-B Model

All comments for the **6IRV-A** relay are applicable to the **6IRV-B**, as the above mentioned external trip inputs will actuate on both reclosers incorporated into the automatic reclose function.

3.19.3 Recloser Start Logic

The Recloser Start Logic is depicted in Figure 3.19.1. As can be seen in this figure, the recloser start can be produced when any of the phase, ground or negative sequence overcurrent elements or the open phase unit is tripped, provided the **Recloser Start Mask** allows it.

Recloser start is also produced when an external trip is detected (if the **A Pole External Trip**, **B Pole External Trip**, **C Pole External Trip** inputs or otherwise the **External Trip** and **External Three-Phase Trip** inputs are programmed). Under all circumstances, the recloser start is equal to the **RCLS** signal activation. The remaining elements generate non-reclosable trips.

The recloser will not start its close sequence if it detects that the number of trips has exceeded the set limit or if **IN_BLKRCLS (Recloser Initiate Block input**) has been activated.

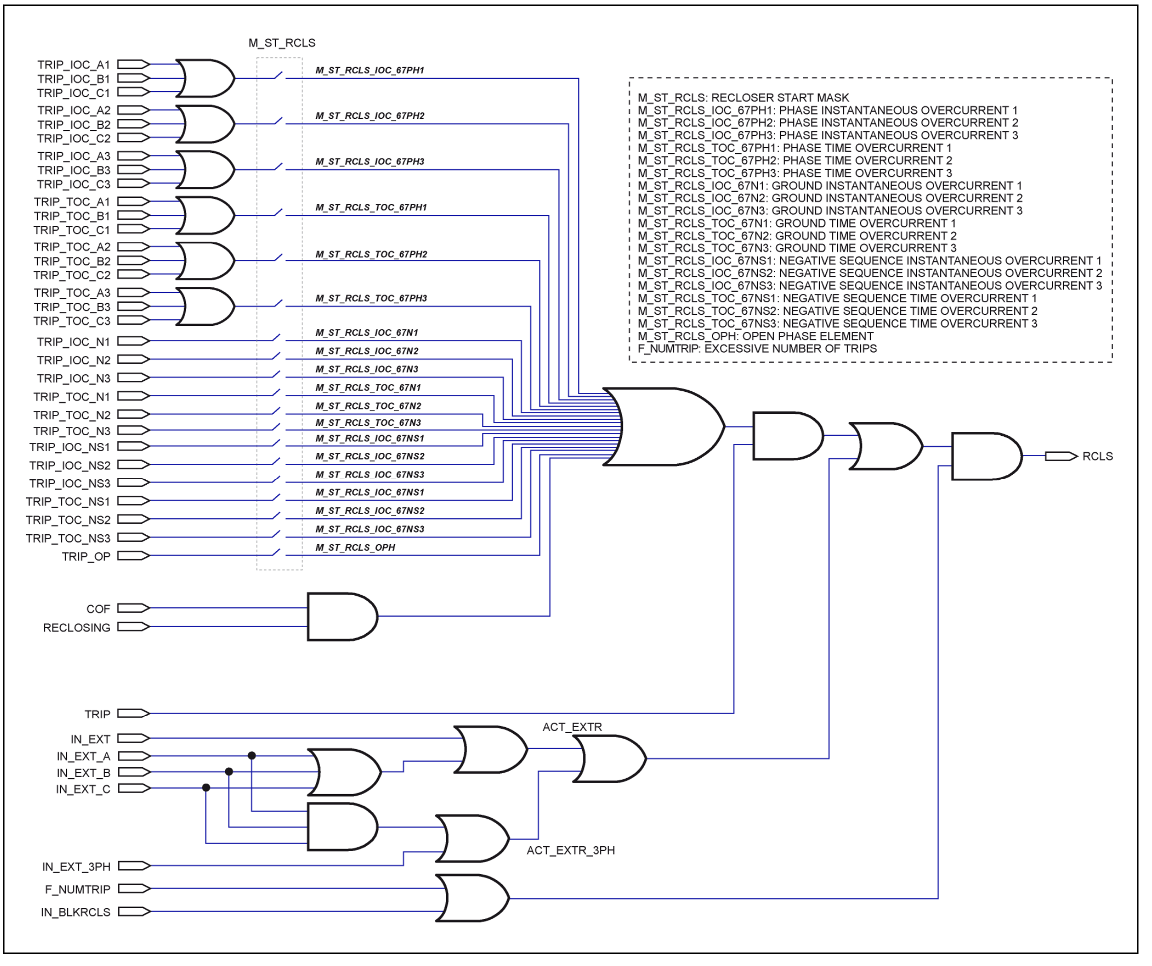


Figure 3.19.1: Recloser Sequence Start Logic Diagram.

3.19.4 Reclosing Logic

3.19.4.a Automatic Reclose with One Recloser

Figures 3.19.2, 3.19.3, 3.19.4 and 3.19.5 depict the flow diagrams for the four different recloser operation modes. Figure 3.19.6 shows the block diagram of the recloser lockout. This last block diagram is common for each of the four reclosing modes.

The flow diagrams of Automatic reclose with two reclosers (**6IRV-B** relays only, see 3.19.5) consider subscripts m (m=1,2) and s (s=1,2; s≠m) for master and slave reclosers respectively. The flow diagrams of the Automatic reclose with one recloser consider the subscript m (m=1,2). Said subscript is only applicable to the **6IRV-B** relay as the operative recloser (recloser 1 or 2) can be selected in this relay. For **6IRV-A** relays said subscript should not be considered.

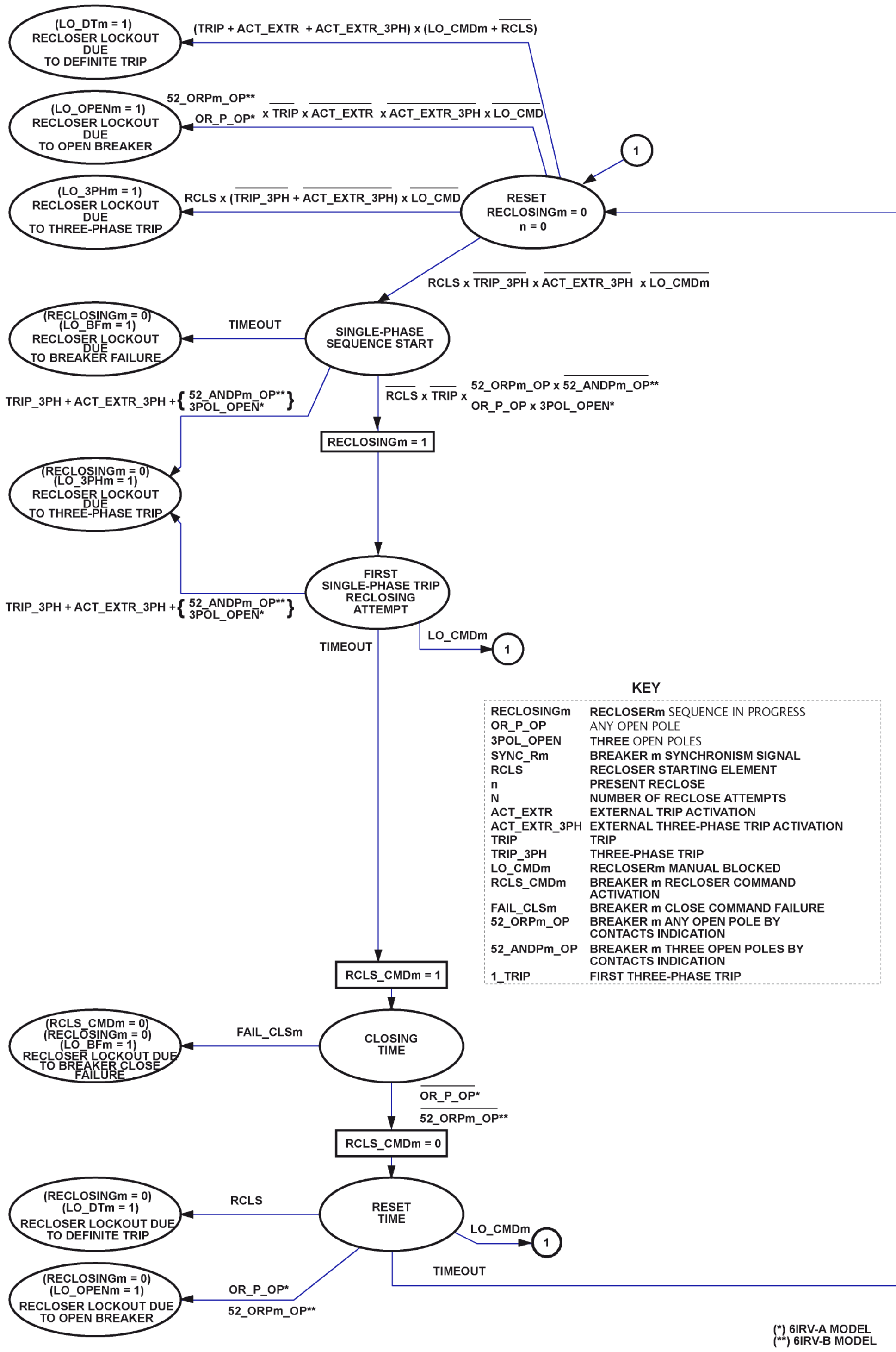


Figure 3.19.2: Recloser 1-P Mode 0peration Flow Diagram (I) (6IRV-A and 6IRV-B Models with One Recloser in Operation).

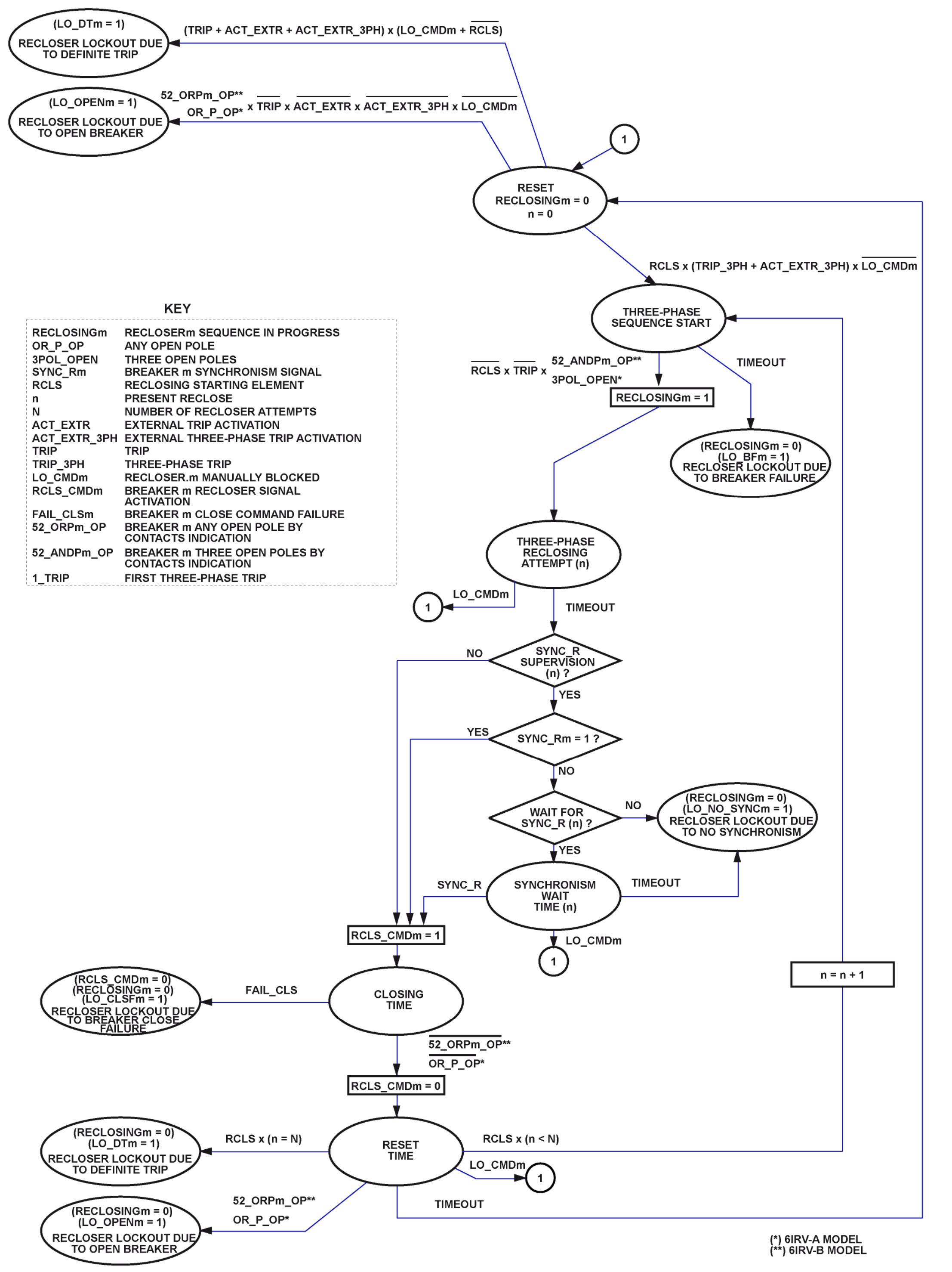


Figure 3.19.3: Recloser 3-P Mode Operation Flow Diagram (I) (6IRV-A and 6IRV-B Models with One Recloser in Operation).

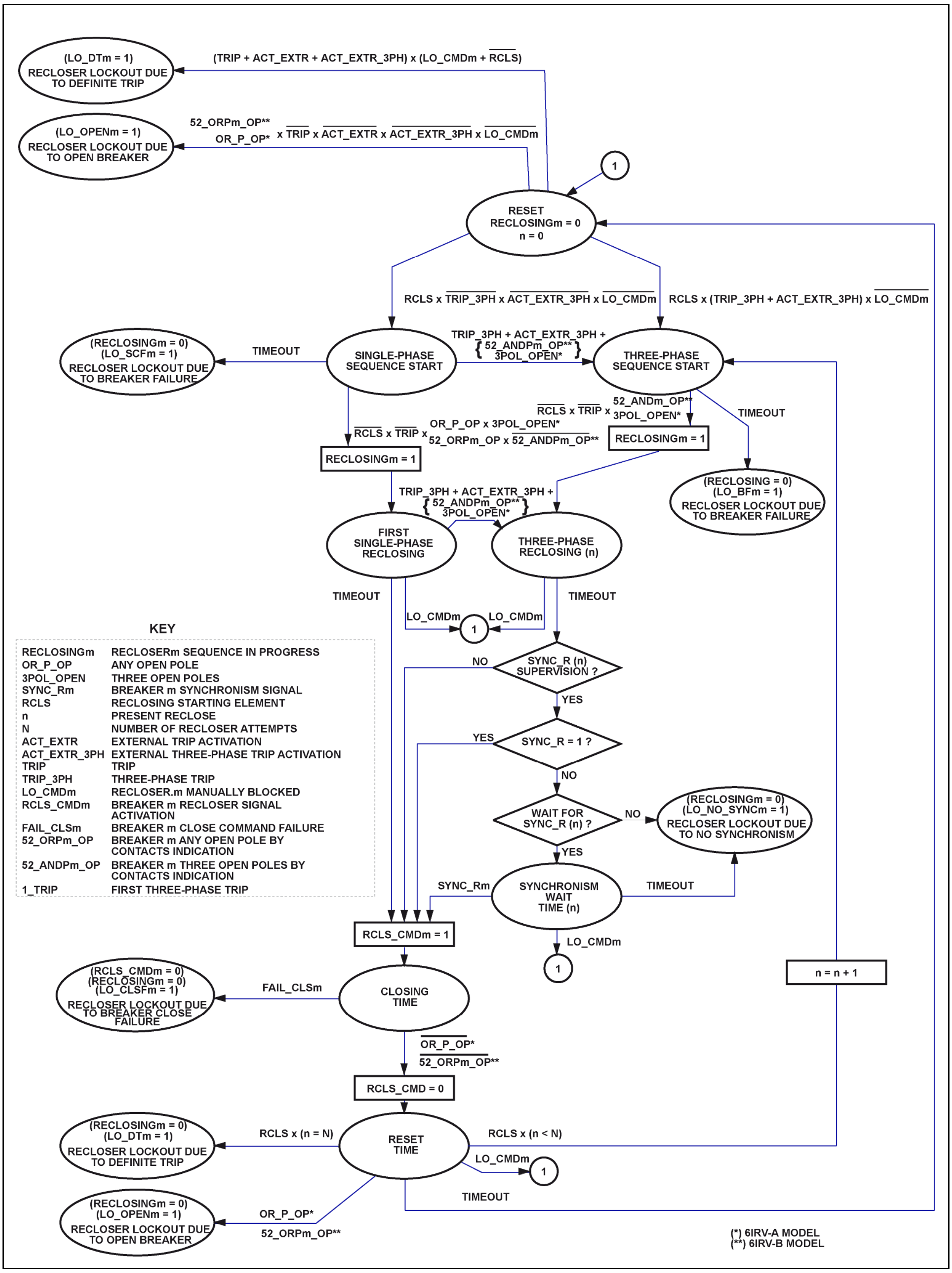


Figure 3.19.4: Recloser 1P / 3P Mode Operation Flow Diagram (I) (6IRV-A and 6IRV-B Models with One Recloser in Operation).

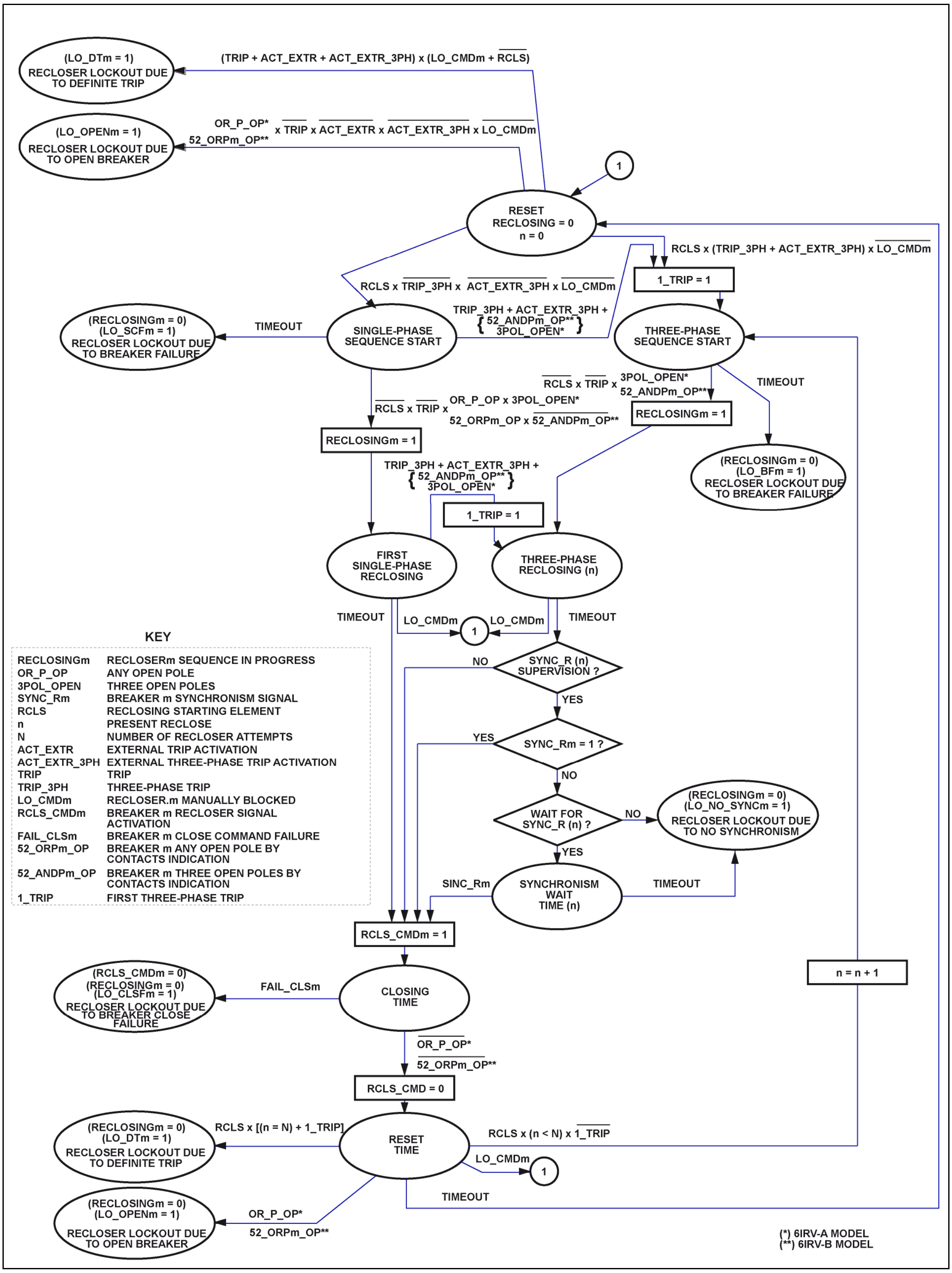


Figure 3.19.5: Recloser Dependent Mode Operation Flow Diagram (I) (6IRV-A and 6IRV-B Models with One Recloser in Operation).

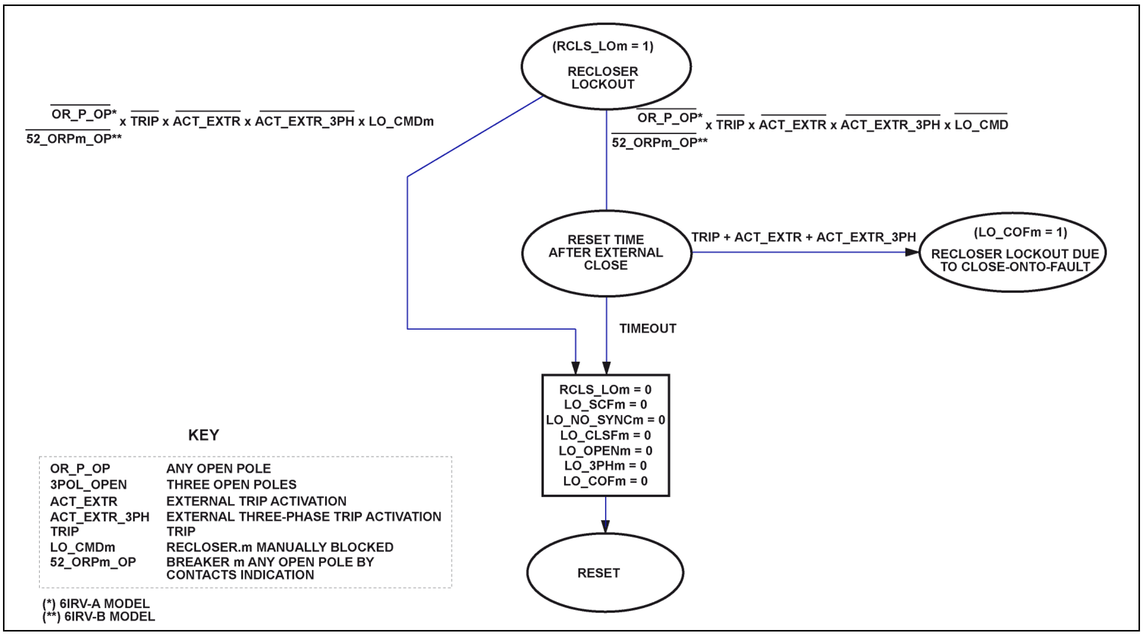


Figure 3.19.6: Recloser Operation Flow Diagram (II) (6IRV-A and 6IRV-B Models with One Recloser in Operation).

3.19.4.b Automatic Reclose with Two Reclosers. 6IRV-B Models

Figures 3.19.7 to 3.19.14 show the flow diagrams of the four reclose or operating modes for both reclosers, master and slave, respectively. Figures 3.19.15 and 3.19.16 shows the flow diagram of the internal lockout state also for both reclosers, master and slave. This last diagram is common for the four reclose modes.

The flow diagrams of Automatic reclose with two reclosers (**6IRV-B** relays only) consider subscripts m (m=1,2) and s (s=1,2; s≠m) for master and slave reclosers respectively.

Key for figures 3.19.7 to 3.19.16:

RECLOSINGm	Recloser m in Sequence in Progress
LO_OPENm/s	Recloser m/s Internal Lockout on Open Breaker
LO_3PHm/s	Recloser m/s Internal Lockout on Three-phase Trip
LO_BFm/s	Recloser m/s Internal Lockout on Initialisation Failure
LO_CLSFm/s	Recloser m/s Internal Lockout on Closing Failure
LO_DTm/s	Recloser m/s Internal Lockout on Final Trip
LO_NO_SYNCm/s	Recloser m/s Internal Lockout on Lack of Synchronism
LO_CFm/s	Recloser m/s Internal Lockout on Switch Onto Fault
LO_MASs	Recloser s Internal Lockout on Master Command
RCLS_LOm/s	Any Recloser m/s Internal Lockout State
RCLS_CMDm/s	Breaker m/s Reclose Command
SLV_PERM	Slave Recloser Enable
SLV_BLK	Slave Recloser Lockout
RCLSm/s_STANBY	Recloser m/s Reset
REPm/s	Reset
E_TINIMm/s	Single-Phase Initation Time
E_TINITm/s	Three-Phase Initation Time
E_TRMm/s	Single-Phase Reclose Time
E_TRTnm/s	Three-Phase Reclose n Time
E_ESP_SINCm/s	Synchronism Waiting Time
E_ESP_CIERm/s	Closing Waiting Time
E_TSEG1m/s	Security Time 1
E_TSEG2m/s	Security Time 2
E_SEG_CMm/s	Security Time after Manual Closing
E_ESP_CESCm	Waiting for Slave Closing
E_MAES_CMs	Waiting for Master after Single-Phase Sequence
E_MAES_CTs	Waiting for Master after Three-Phase Sequence
$\mathbf{n_m}$	Reclose Sequence Recloser m
$\mathbf{n_s}$	Reclose Sequence Recloser s
N	Adjust Sequence Recloser Number

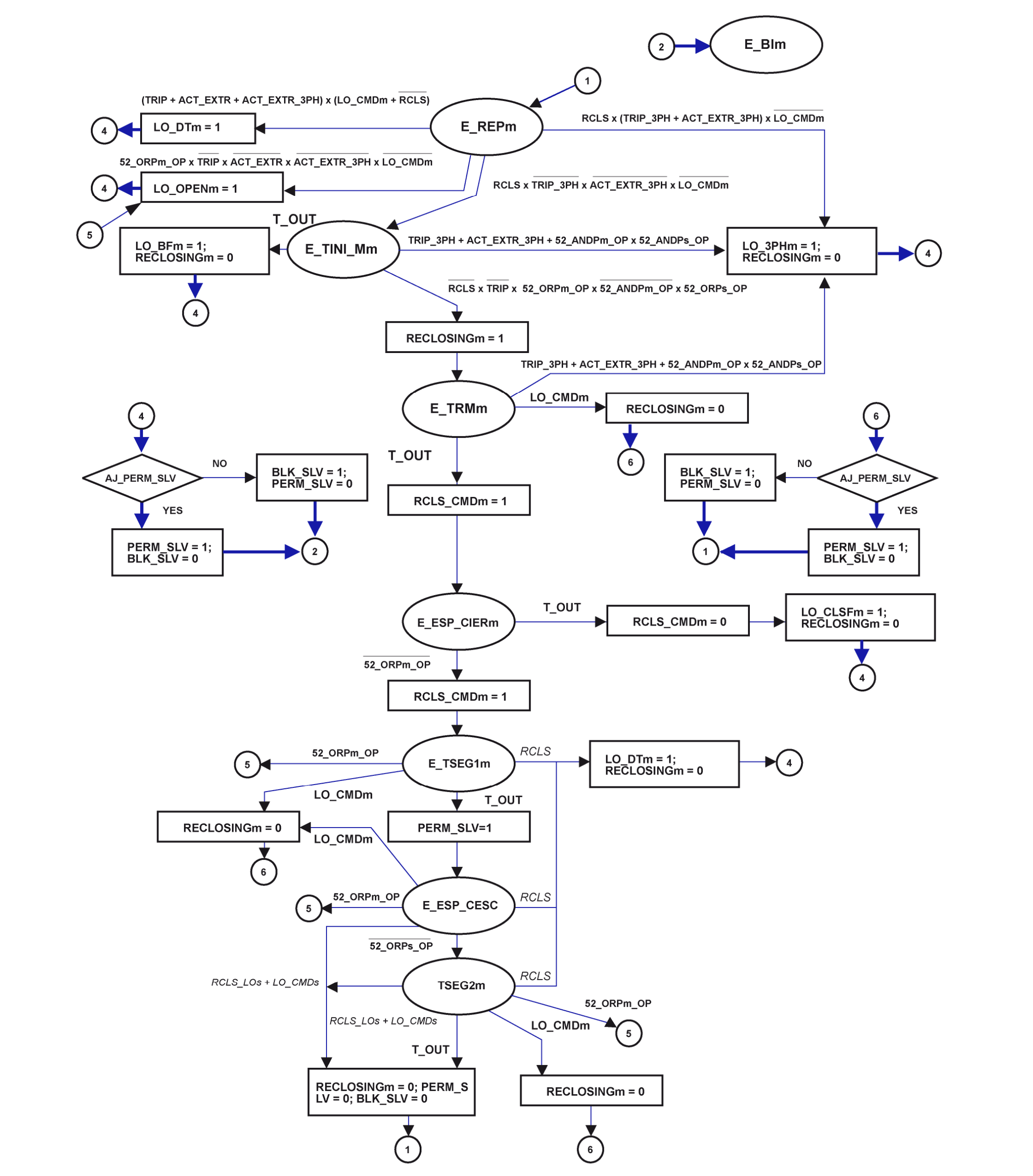


Figure 3.19.7: 1P Mode Master Recloser (6IRV-B).

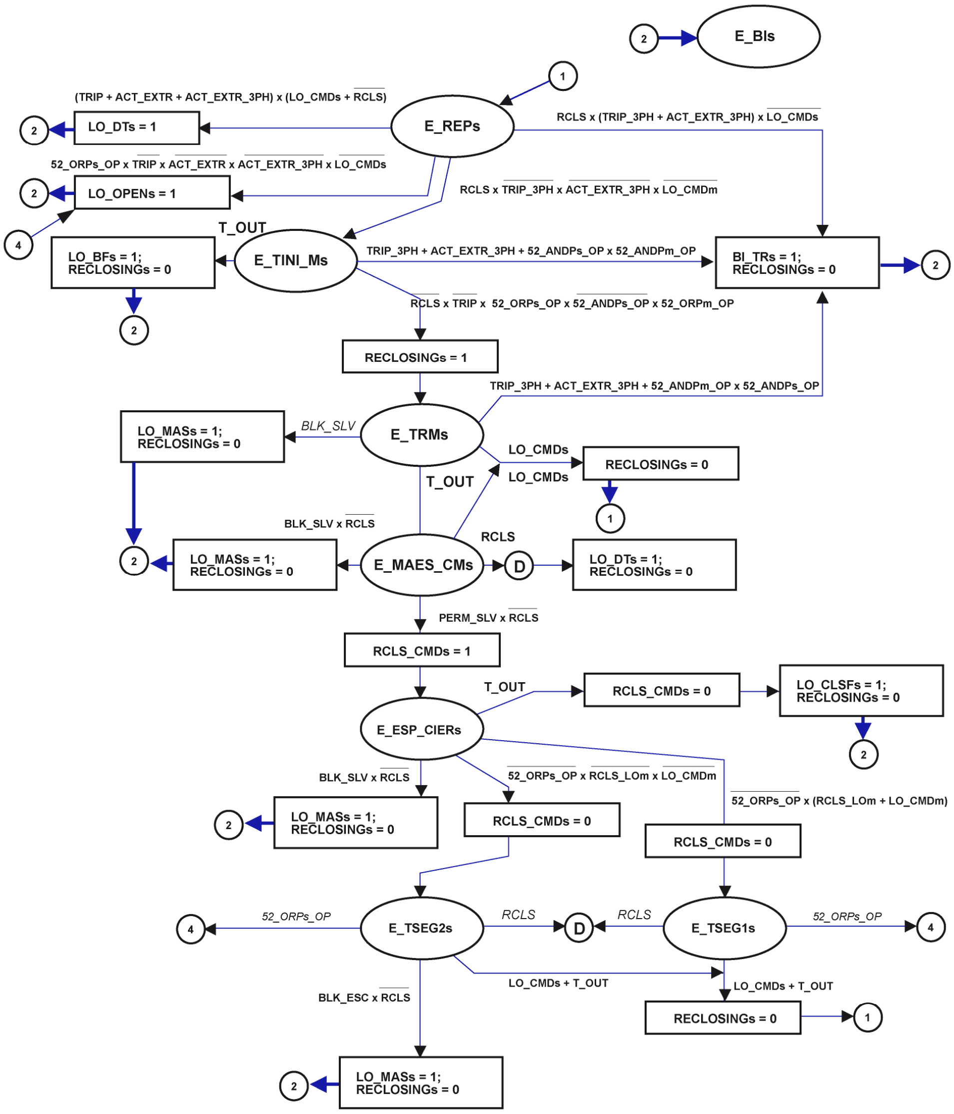


Figure 3.19.8: 1P Mode Slave Recloser (6IRV-B).

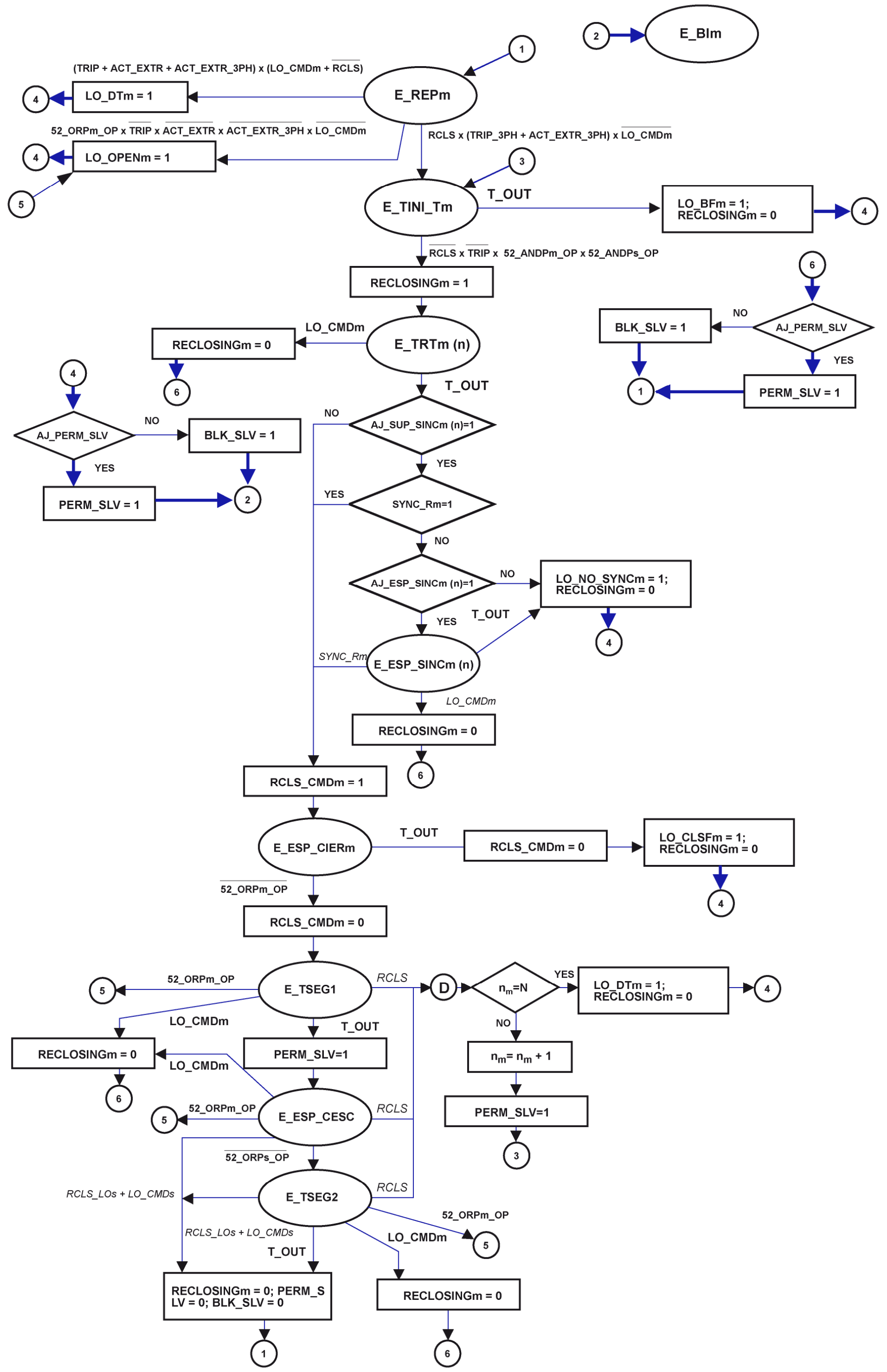


Figure 3.19.9: 3P Mode Master Recloser (6IRV-B).

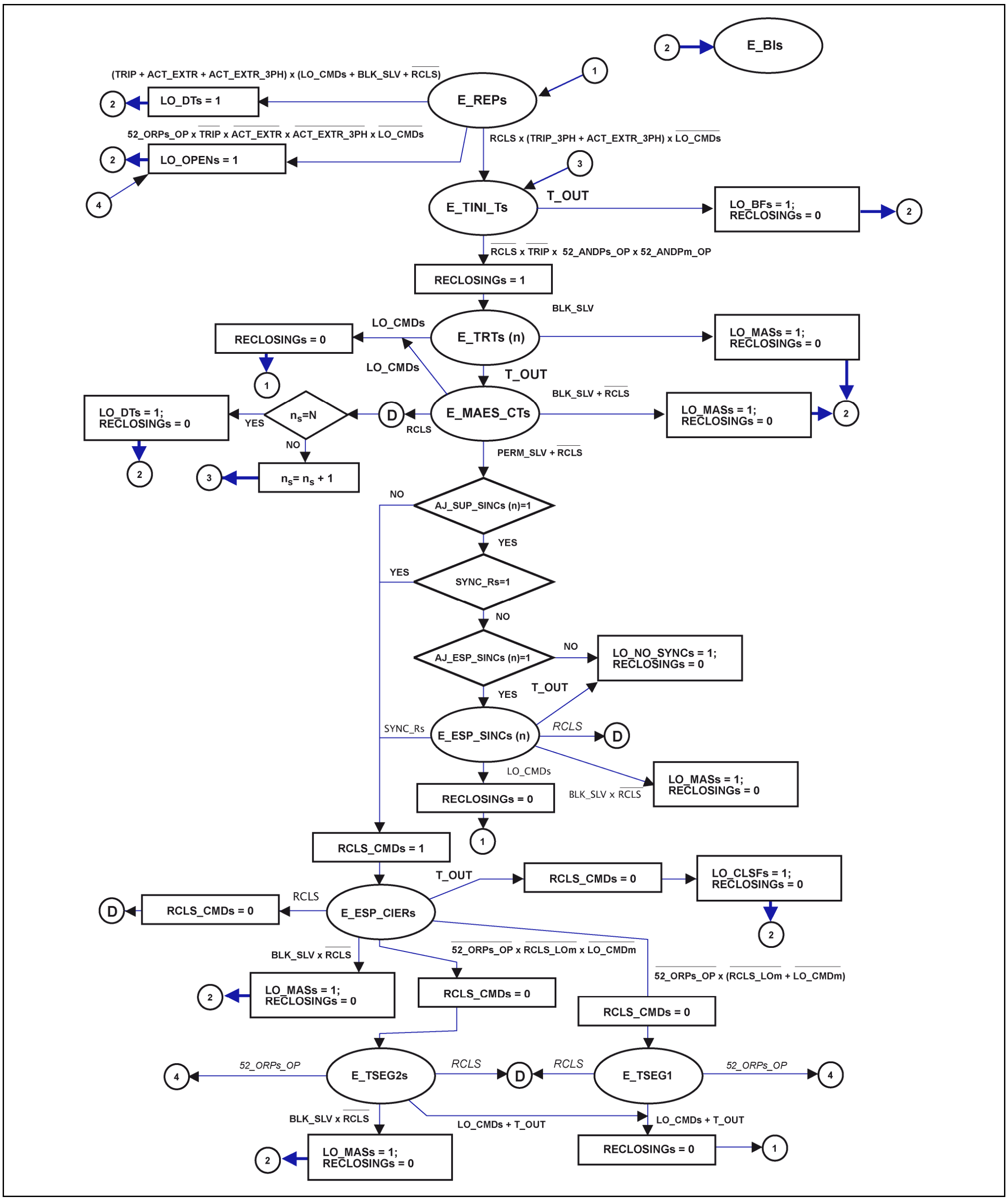


Figure 3.19.10: 3P Mode Slave Recloser (6IRV-B).

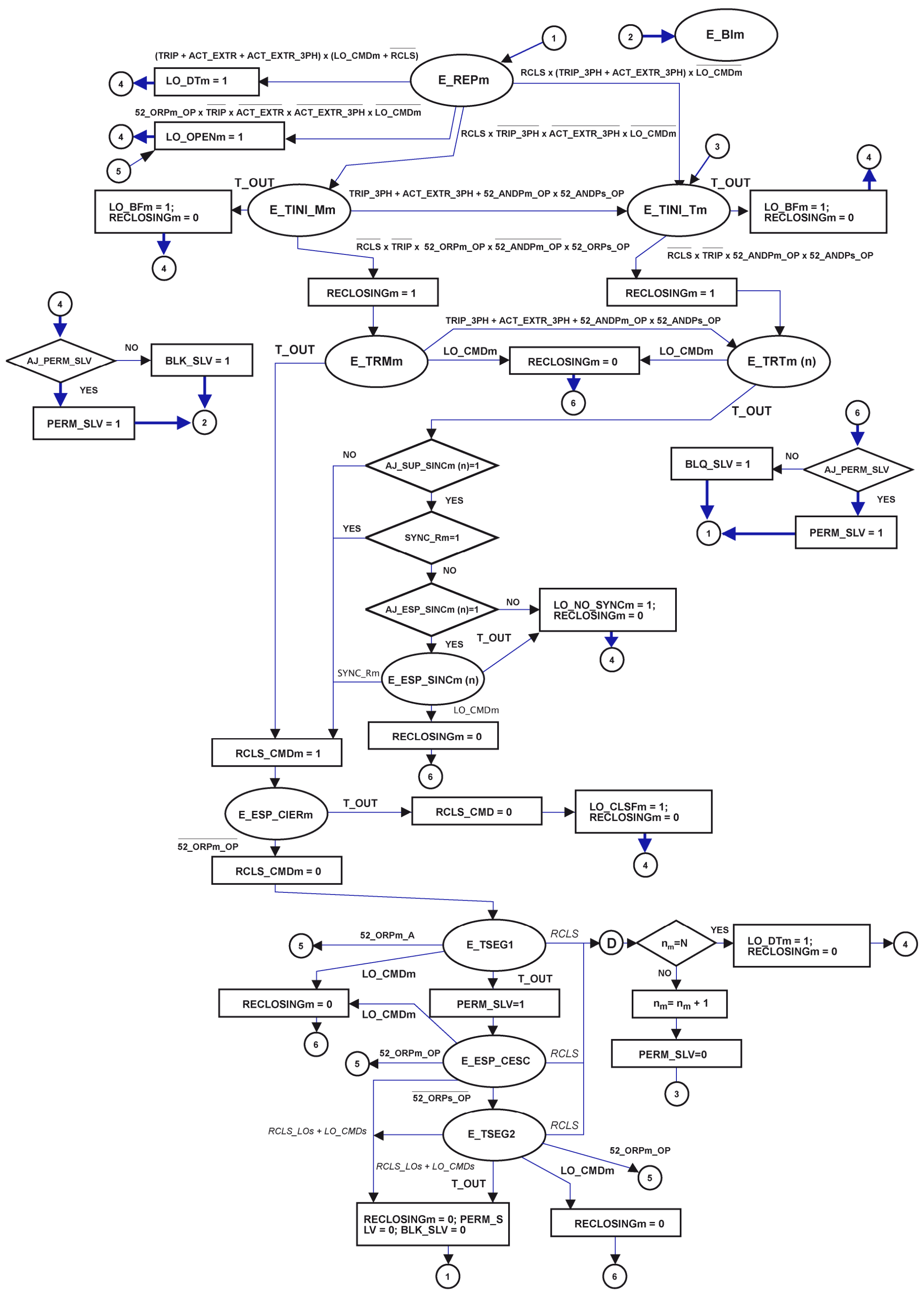


Figure 3.19.11: 1P/3P Mode Master Recloser (6IRV-B).

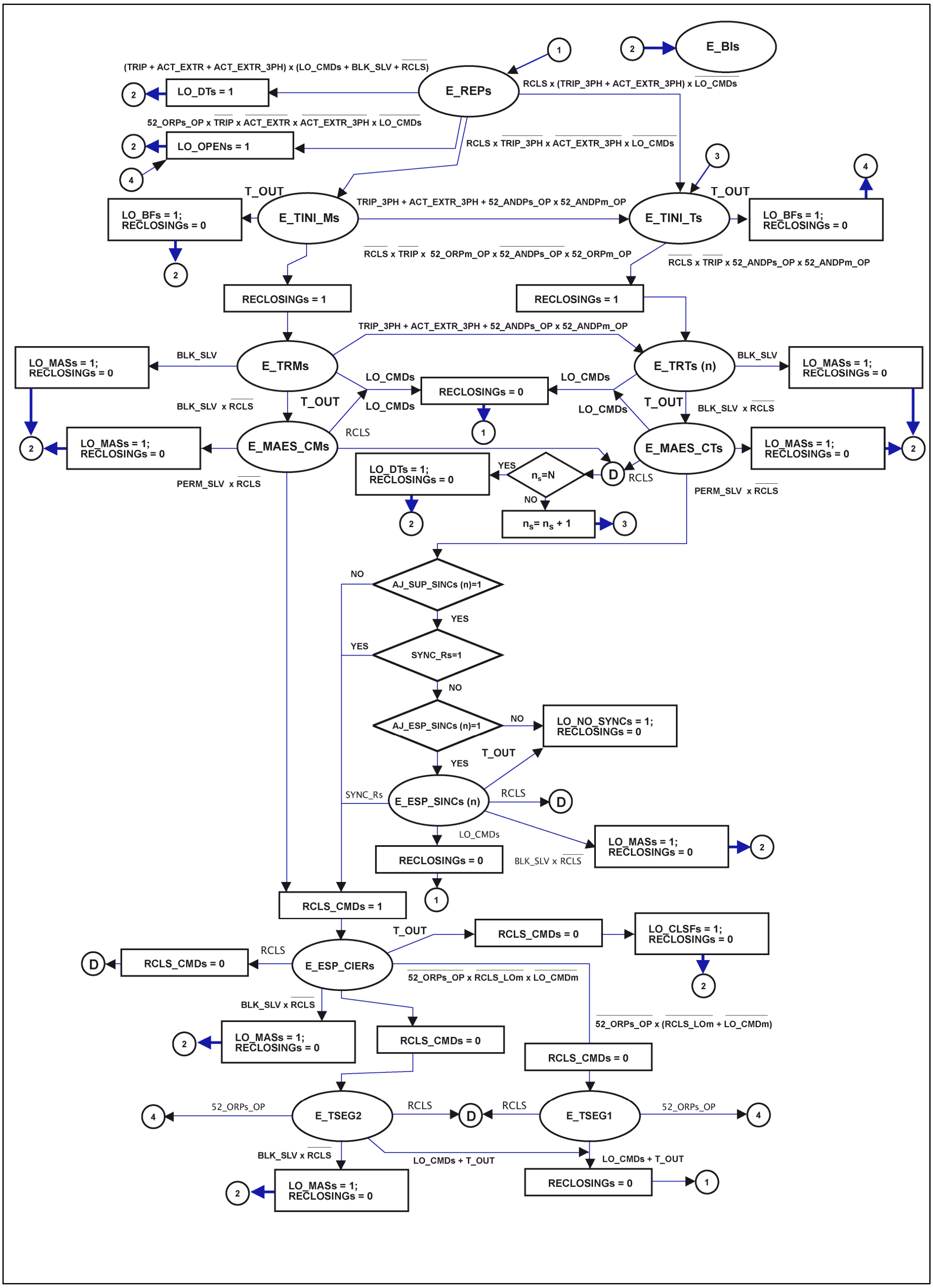


Figure 3.19.12: 1P/3P Mode Slave Recloser (6IRV-B).

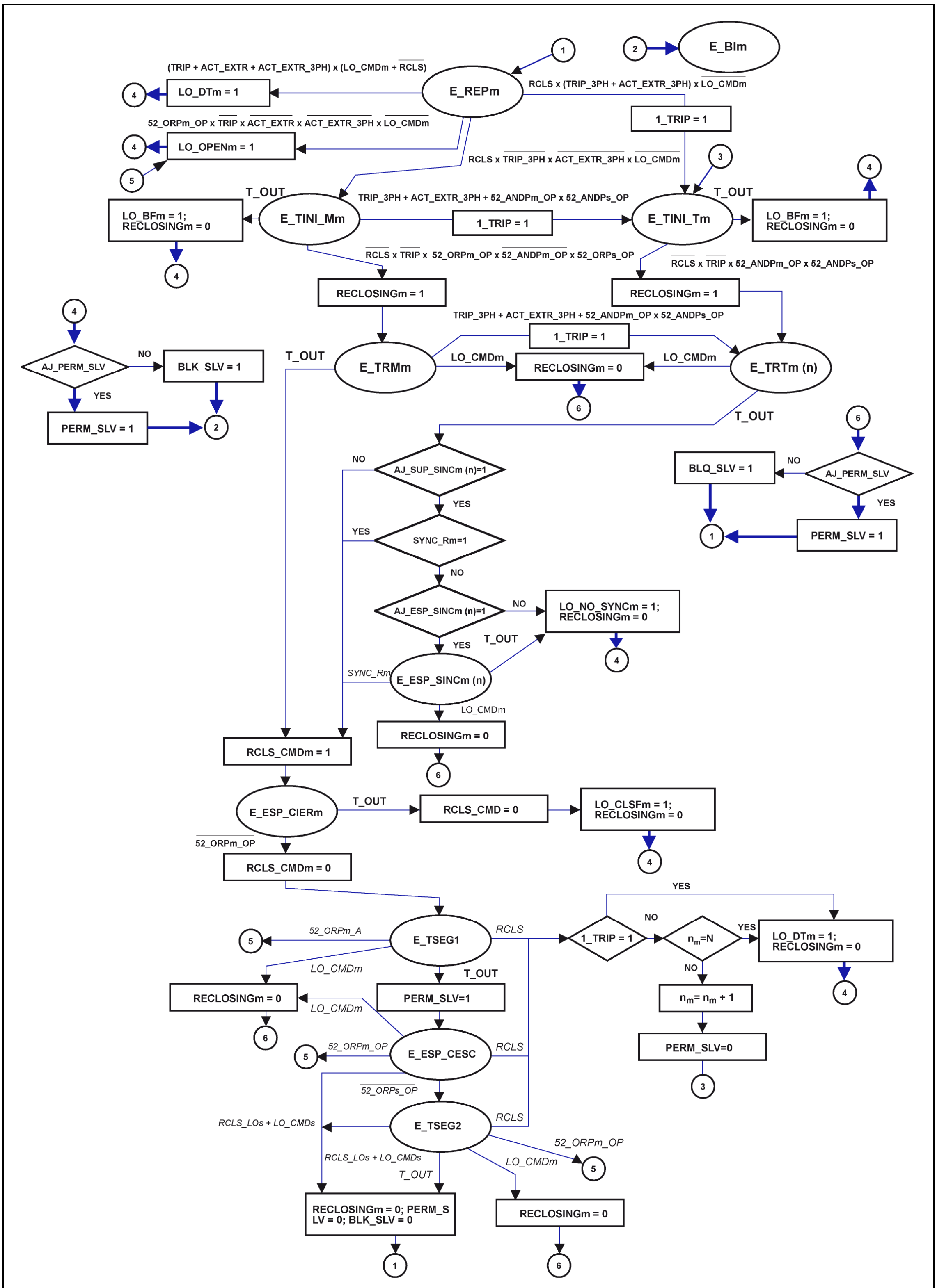


Figure 3.19.13: Dependent Mode Master Recloser (6IRV-B).

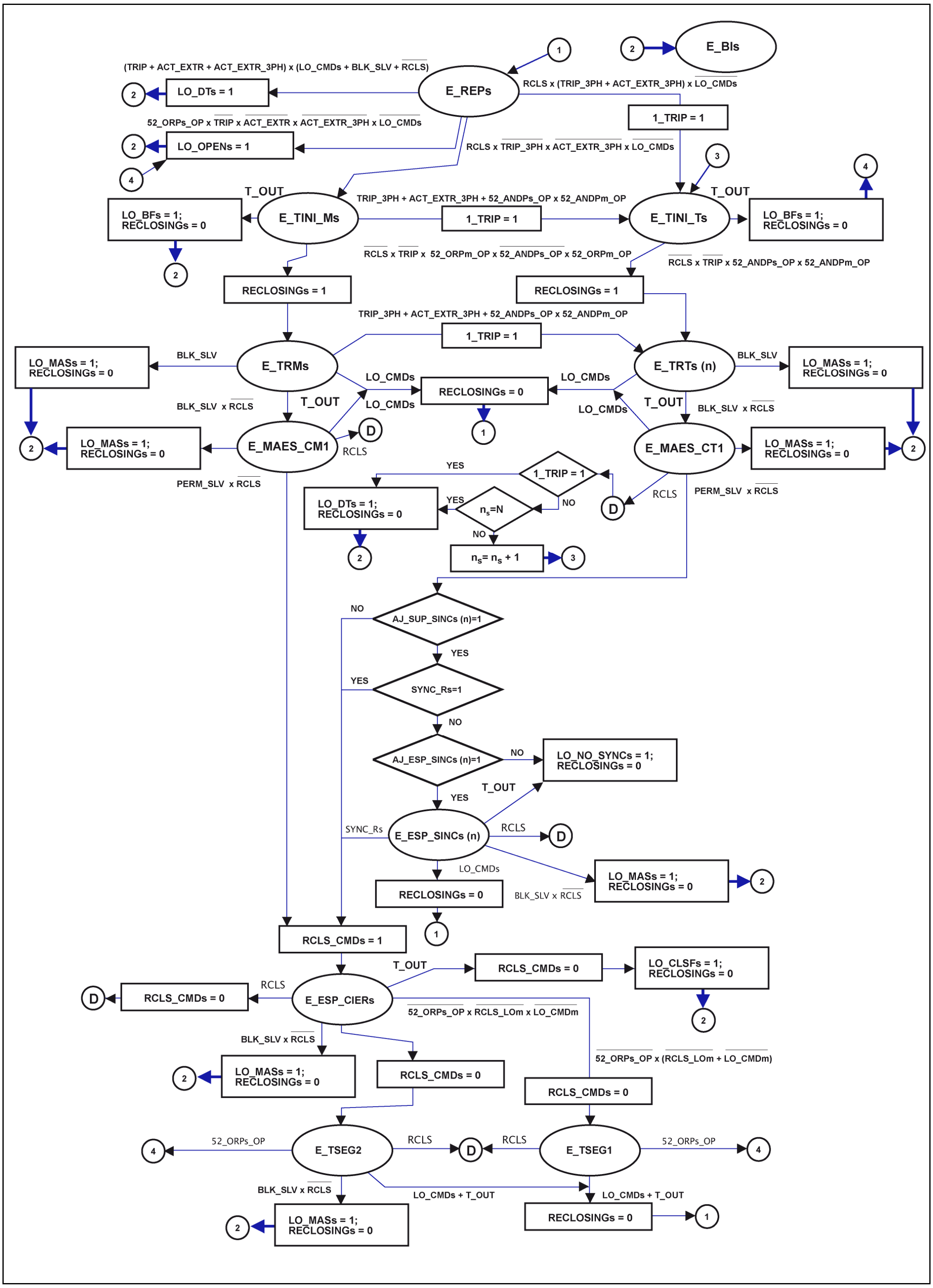


Figure 3.19.14: Dependent Mode Slave Recloser (6IRV-B).

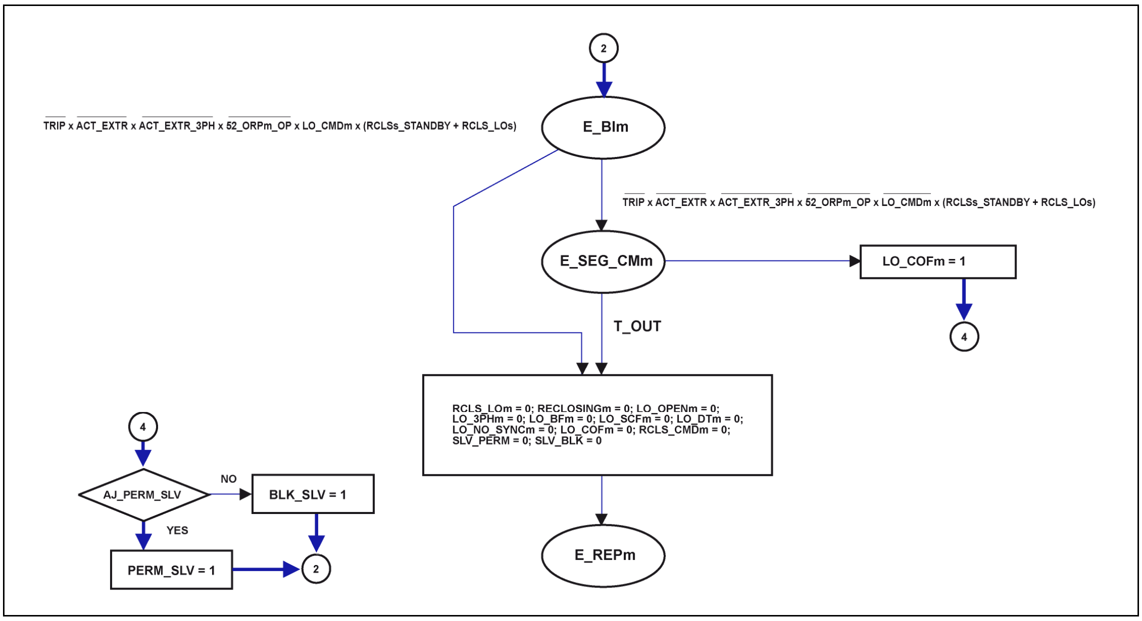


Figure 3.19.15: Internal Blocking Master Recloser (6IRV-B).

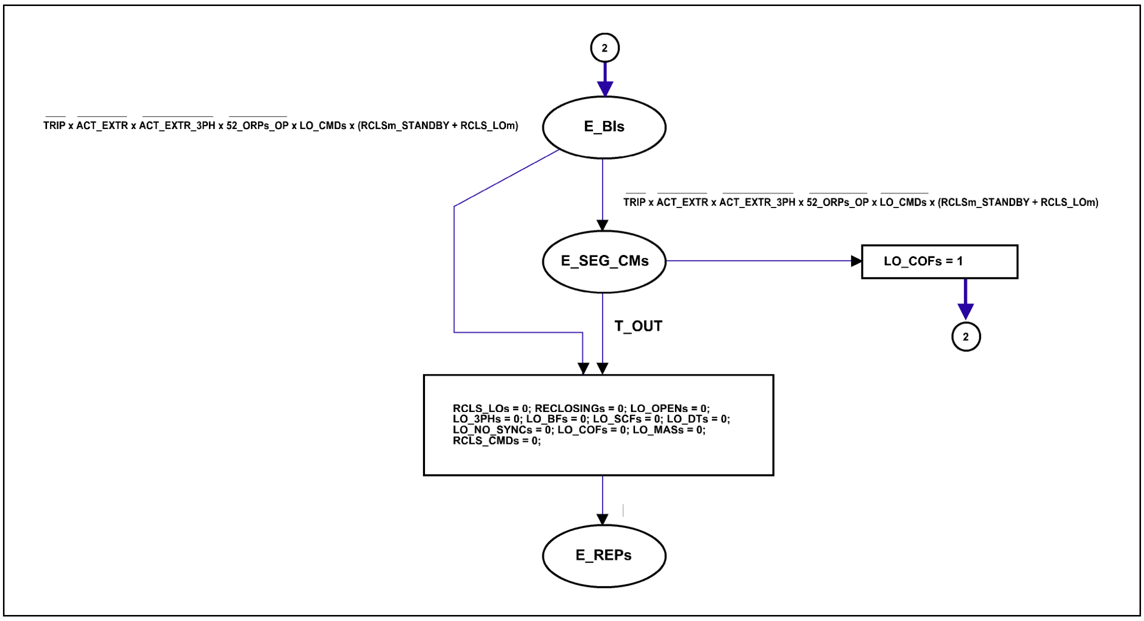


Figure 3.19.16: Internal Blocking Slave Recloser (6IRV-B).

3.19.5 Reclose Sequence

Up to four reclose attempts can be programmed in the reclose sequence. A sequence of operations takes place during each of these close attempts which is controlled by the recloser settings and by certain external events, detected through the digital input system or received from the protection units contained in the **6IRV** IED itself.

Below are represented the different states of the automatic reclose function, with only one recloser (**6IRV-A** models and **6IRV-B** relays when selecting **1 Recloser** option through the **Reclosers in operation** setting) or two reclosers (**6IRV-B** relay when selecting **2 Reclosers** through the **Reclosers in operation** setting).

3.19.5.a Sequence Start

- **Automatic Recloser with 1 Recloser**

The **6IRV** Recloser presents two start time states (**Single-Phase Start Time** state and **Three-Phase Start Time** state).

When the recloser is in the Recloser Reset state, reclosing is initiated as follows:

- In **1P Mode**, the operation starts on a single-phase trip being produced by any of the enable protection units or by the **External Trip Activation** (**ACT_EXTR**) signal, with the **External Three-Phase Activation Trip** (**ACT_EXTR_3PH**) deactivated.

  In either of the two cases, the **RCLS** signal will be activated, which will remove the Recloser from its Reset state to change it to the Single-Phase Start Time state provided the recloser is not blocked by command (see 3.19.7).

  If the **RCLS** activation is due to **Three-Phase Trip** (**TRIP_3PH** or **ACT_EXTR_3PH**), the Recloser evolves the Internal **Blocking Due to Three-Phase Trip** state instead of starting a reclose sequence.

- In **3P Mode**, the operation starts on one of the enabled protection units producing a three-phase trip or by the **External Three-Phase Activation Trip** (**ACT_EXTR_3PH**) signal.

  In either of the two cases, the **RCLS** signal will be activated, which will remove the Recloser from its Reset State to change it to the **Three-Phase Start Time** state provided the recloser is not blocked by command (see 3.19.7).

- In **1p/3p** and **Dependent** modes, the operation of the Recloser is based on the combination of the two previous modes (**1p** for single-phase trips and **3p** for three-phase trips).

Single-Phase Sequence Start

In the **Single-Phase Start Time** state, a time counter with **Start Time** setting is put into operation. If this time ends before detecting the fault reset (**RCLS** reset), the opening of the breaker ($OR\_P\_OP \times \overline{AND\_P\_OP}$ in **6IRV-A** relays or $52\_ORPm\_OP \times \overline{52\_ANDPm\_A}$ in **6IRV-B** relays) and the trip drop (**TRIP**), the system evolves to the **Internal Blocking Due to Breaker Failure** state, from which it can only leave through a **Close Command** to the breaker (see 3.19.6). Otherwise, the single-phase sequence starts activating the **RECLOSINGm** (Sequence in Progress) signal and generating the Recloser Sequence Start event.

Note: The RECLOSINGm signal will remain activated during the entire recloser m sequence, since the first attempt sequence will continue until the recloser switches to the Reset or the Lockout state.

If the single-phase trip evolves to three-phase before the initiate timer times out, the Recloser switches to:

- **Internal Lockout on Three-Phase Trip**, in **1p Mode**
- **Three-Phase Initiate Time**, in **1p/3p** and **Dependent Modes**

Three-Phase Sequence Start

In the **Three-Phase Start Time** state, a time counter is put into operation with the **Start Time** setting. As in the single-phase case, if this time ends before the fault reset is detected (**RCLS** reset), the opening of the breaker (**OR_P_OP** in **6IRV-A** relays or **52_AND_OPm** in **6IRV-B** relay) and trip drop (**TRIP**), the system evolves to the Internal Blocking Due to Breaker Failure state, from which it can only leave through a **Close Command** to the breaker (see 3.19.6). Otherwise, the three-phase sequence commences activating the **RECLOSINGm** (Sequence in Progress) signal and generating the Recloser Sequence Start event.

Note: The RECLOSINGm signal will remain activated during the entire recloser m sequence, since the first attempt sequence will continue until the recloser switches to the Reset or the Lockout state.

If the single-phase trip evolves to three-phase (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or if the breaker opens its three poles (activation of **AND_P_OP** in **6IRV-A** relays or **52_ANDPm_OP** in **6IRV-B** relay only) before the initiate timer times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip**, in **1p Mode**.
- **Three-Phase Initiate Time**, in **1p/3p** and **Dependent** Modes.

- **Automatic Reclose with Two Reclosers: Master Recloser (m) and Slave Recloser (s). 6IRV-B Models**

Both **6IRV-B** relay reclosers, whether master or slave, has two initiate time states (**Single-phase Start Time** state and **Three-phase Start Time** state).

Starting from a reset situation, the recloser operation initiates as follows:

- In **1p Mode**, the operation initiates upon a single-phase trip by any enabled protection element or by the **External Trip Activation** (**ACT_EXTR**) signal, the **External Three-phase Trip Activation** (**ACT_EXTR_3PH**) being deactivated. In either case, signal **RCLS** will be activated, bringing each recloser to the **Single-phase Start Time**, provided they are not blocked by command (see paragraph 3.19.7). If **RCLS** is activated by a three-phase trip (**TRIP_3PH** or **ACT_EXTR_3PH**), the recloser evolves to **Internal Lockout on Three-phase Trip** state instead of initiating a reclose sequence.

- In **3p Mode**, the operation initiates upon a three-phase trip by any enabled protection element or by the **External Three-phase Trip Activation** (**ACT_EXTR_3PH**) signal. In either case, signal **RCLS** will be activated, which will bring each recloser out of the Reset state into the **Three-phase Start Time** state, provided they are not blocked by command (see paragraph 3.19.7).

- In **1p/3p** and **Dependent Modes**, recloser operation is based on the combination of the two modes above (**1p** for single-phase trips and **3p** for three-phase trips).

The above conditions, initiating the recloser operation (switching from the **Reset** state into the **Initiate Time** state), are the same for both reclosers, whether master or slave, so that, if neither is blocked by command, both will switch into the same **Start Time** state (single-phase or three-phase) and this will happen at the same time.

Single-phase Sequence Start for the Master Recloser (m)

At **Single-phase Start Time** state a timer set to **Start Time** setting starts timing. If the timer times out before detecting the reclose initiate signal reset (**RCLS**), the single-phase opening of the breaker associated to the master recloser ($52\_ORPm\_OP \; x \; \overline{52\_ANDPm\_A}$), the opening of any pole of the other breaker (**52_ORPs_OP**) and the trip (**TRIP**), the recloser evolves to the **Internal Lockout on Start Failure** state, which can only be reset under the conditions stated in paragraph 3.19.6. Otherwise, the single-phase sequence initiates and the **RECLOSINGm** (**Recloser m in Sequence in Progress**) signal activates.

Note: the RECLOSINGm signal remains active for the complete recloser m sequence (from the start of the first sequence until the recloser resets or switches to internal lockout).

If the single-phase trip evolves to three-phase (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or both breakers open their three poles (**52_ANDPm_OP x 52_ANDPs_OP**) before the **Start Time** times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**
- **Three-Phase Start Time** state, in **1p/3p** and **Dependent Modes**

The activation of any of the above mentioned **Master Recloser Internal Block** signals, **LO_BFm** (**Recloser m Internal Lockout on Start Failure**) or **LO_3PHm** (**Recloser m Internal Lockout on Three-phase Trip)** generates the **Block** or **Slave Recloser Enable** signals (**BLK_SLV** and **PERM_SLV** respectively) as a function of the **Slave Recloser Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

Single-phase Sequence Start for the Slave Recloser (s)

The above comments on the master recloser are applicable to the slave recloser (swapping the variables m and s), except with regard to **Block** and **Slave Reclose Enable** signal generation, which are characteristic of the master recloser.

As mentioned above, in order for a recloser **Single-phase Start Time** state to reset, apart from **Recloser Start** signal reset, **Trip** and **Single-phase Opening** of the breaker associated to said recloser, the opening of any pole of the breaker associated to the second recloser is required. If said opening has been single-phase, the **Single-phase Start Time** state of both reclosers, master and slave, will reset simultaneously. If the opening has been three-phase, the second recloser will switch to **Internal Lockout on Start Failure**, so that only the first recloser will initiate the reclose sequence.

Three-phase Sequence Start for the Master Recloser (m)

At **Three-phase Start Time** state a timer set to **Start Time** setting starts timing. If the timer times out before detecting the **Reclose Start** signal reset (**RCLS**), the three-phase opening of the two breakers (**52_ANDPm_OP** and **52_ANDPs_OP**) and the trip (**TRIP**), the master recloser evolves to the **Internal Lockout on Start Failure** state, which can only be reset under the conditions stated in paragraph 3.19.6. Otherwise, the three-phase sequence initiates and the **RECLOSINGm** (**Recloser m in Sequence in Progress**) signal activates.

Note: the RECLOSINGm signal remains active for the complete recloser m sequence (from the start of the first sequence until the recloser resets or switches to internal lockout).

The activation of any of the above mentioned master recloser **Internal Block** signals, **LO_BFm** (**Recloser m Internal Lockout on Start Failure**) or **LO_3PHm** (**Recloser m Internal Lockout on Three-phase Trip)** generates the **Block** or **Slave Recloser Enable** signals (**BLK_SLV** and **PERM_SLV** respectively) as a function of the **Slave Recloser Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

Three-phase Sequence Start for the Slave Recloser (s)

The above comments on the master recloser are applicable to the slave recloser (swapping the variables m and s), except with regard to **Block** and slave recloser **Enable** signal generation, which are characteristic of the master recloser.

Inasmuch as the condition to reset the **Three-phase Start Time** state is the same for both reclosers, in case it is complied with, both reclosers will reset at the same time. Otherwise both will switch, also at the same time, to the **Internal Lockout on Start Failure** state.

3.19.5.b Reclosing Timer (Dead Time)

- **Automatic Recloser with 1 Recloser**

There are two different reclosing timers, according to the single-phase or three-phase character of the Reclose start. In both cases, the activation of the **Reclose Command** (**RCLS_CMDm**) will produce the activation of the **Command CLOSEm** output, with the latter giving a **Close Command** to the breaker.

Single-Phase Reclosing Timer

On entering this state (which only occurs in the first sequence of the **1P** and **1P/3P** modes), the adjusted **First Single-Phase Reclosing Time** will commence to be counted.

If a recloser block command is issued (activation of **LO_CMDm**) before the timer times out, the recloser resets without reclosing. On the other hand, if the single-phase trip evolves to three-phase (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or if the breaker opens the three poles (activation of signals **AND_P_OP** in **6IRV-A** relays or **52_ANDPm_OP** in **6IRV-B** relay) before the single-phase reclose time times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**.
- **Three-Phase Initiate Time** state, in **1p/3p** and **Dependent** Modes.

Otherwise, if the counted timer times out the **Reclose Command** signal (**RCLS_CMD**) is generated and the **Closing Time** state is achieved.

Three-Phase Reclosing Timer

When the Three-Phase Reclosing Timer state is achieved, the corresponding timer will be started:

- The **First Three-Phase Reclosing Timer** will start for the first reclosing attempt after a three-phase trip.
- The **Second, Third or Fourth Reclosing Timer** will start for a second, third or fourth reclosing sequence (as previously noted, only three-phase reclosing is possible after the first recloser sequence).

As in the case of Single-Phase Reclosing Time, if the Recloser is manually blocked (**LO_CMDm** activation) before the count ends, the Recloser returns to Reset state without reclosing. On the other hand, if the count ends, it is verified if synchronism conditions exist and then **RCLS_CMDm** (**Reclose Command**) is activated if the synchronism conditions have been previously fulfilled.

The **Synchronism Supervision** setting may be adjusted independently for each Recloser sequence. If the **Synchronism Supervision** setting for the corresponding sequence is set to **NO**, the **Reclose Command** signal (**RCLS_CMDm**) is generated and the **Closing Time** state is achieved.

If the **Synchronism Supervision** setting for the corresponding sequence is set to **YES**, the next step is to check the **SYNC_Rm** signal, which indicates the presence of synchronous conditions*. If this signal is activated, the **Reclose Command** signal (**RCLS_CMDm**) is generated and the **Closing Wait Time** state is achieved.

When synchronous conditions are not reached* (**SYNC_Rm** deactivated), the **Synchronism Timer Enable** setting, independently adjustable for each of the three possible sequences of the recloser function, is checked. If this setting is set to **NO**, the recloser changes to the **Internal Lockout Due to Lack of Synchronism** state. If the setting is set to **YES**, the **Synchronism Wait Timer** starts to count down the adjusted time.

Activation of the **SYNC_Rm** signal before timeout generates activation of the **Reclose Command** signal (**RCLS_CMDm**), and the **Closing Time** state is achieved. If the **SYNC_Rm** signal is not activated before timeout, the Recloser changes to the Internal **Lockout Due to Lack of Synchronism** state.

(*) For models 6IRV-A ** - ** 2 * or higher, only the synchronism indicated by unit 1 of the synchronism unit itself will be supervised.**

- **Automatic Reclose with Two Reclosers. 6IRV-B Models**

For both reclosers, master and slave, there exist two reclose time waiting states, as a function of the single-phase or three-phase character of the reclose initiation. In both cases, the activation of the **Reclose command** (**RCLS_CMDm/s**) will cause the activation of the **CLOSEm/s Command** output, the latter issuing a **Close command** to the corresponding breaker.

Master Recloser (m) Single-Phase Reclose Time

When this state is reached (which only occurs on the first sequence of **1p** and **1p/3p Modes**) the **First single-phase reclose time** setting starts timing.

If a **Recloser Block Command** is issued (activation of **LO_CMDm**) before the timer times out, the master recloser resets without reclosing. On the other hand, if a three-phase trip occurs (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or both breakers open their three poles (**52_ANDPm_OP and 52_ANDPs_OP**) before the **Single-Phase Reclose Time** times out, the master recloser switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**.
- **Three-Phase Reclose Time** state, in **1p/3p** and **Dependent** Modes.

But, if the **Single-Phase Reclose Time** times out, **RCLS_CMDm** (**Breaker m Reclose Command**) activates and **Close Waiting Time** state is reached.

Activating **LO_3PHm** (**Recloser m Internal Lockout on Three-phase Trip**) or **LO_CMDm** (**Recloser m Lockout on Command)** signals generates the **Block** or **Slave Recloser Enable** signals (**BLK_SLV** and **PERM_SLV** respectively) as a function of the **Slave Recloser Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

Slave Recloser (s) Single-Phase Reclose Time

When this state is reached (which occurs only in the first sequence of **1p** and **1p/3p Modes**) the **First Single-phase Reclose Time** setting starts timing.

If a **Recloser Block Command** is issued (activation of **LO_CMDm**) before the timer times out, the slave recloser resets without reclosing. On the other hand, if a **Three-phase Trip** occurs (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or both breakers open the three poles (**52_ANDPm_OP** and **52_ANDPs_OP**) before the **Single-phase Reclose Time** times out, the master recloser switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**.
- **Three-Phase Reclose Time** state, in **1p/3p** and **Dependent** Modes.

Similarly, if the master recloser activates the **Slave Recloser Block Command**, this will go into **Internal Lockout on Master Command** state, which will reset only if the conditions stated in paragraph 3.19.6 are complied with.

If the **Single-phase Reclose Time** times out, the slave recloser switches to **Waiting for Master Recloser after Single-Phase Sequence** state.

Master Recloser (m) Three-Phase Reclose Time

When going into this state the corresponding set time starts timing:

- **First Three-phase Reclose Time**, when it refers to the first reclose due to a three-phase trip.
- **Second, Third or Fourth Reclose Time**, when it refers to a second, third or fourth retry (as mentioned above, recloses other than the first will always be three-phase).

Similarly than for the single-phase sequence, if a **Recloser Block Command** is issued (activation of **LO_CMDm**) before the timer times out, the recloser **Resets** without reclosing. On the other hand, if the timer times out, synchronism conditions are checked.

First, **Synchronism Supervision Enable** setting value, adjustable separately for each of the three possible sequences and for each breaker, is checked. If the setting corresponding to the present sequence is set to **NO**, **RCLS_CMDm** (**Breaker m Reclose Command**) is issued and **Close Waiting Time** state is reached.

On the other hand, if the enable setting is **YES**, the **SYNC_Rm** state is checked, which states the presence of synchronism for the breaker m. If said signal is activated, **RCLS_CMDm** is issued and **Close Waiting Time** state is reached.

If there is no synchronism (**SYNC_Rm** deactivated), **Synchronism Waiting Enable** setting value, adjustable separately for each of the three possible sequences and for each breaker, is checked. If the setting corresponding to the present sequence is set to **NO**, the recloser goes into **Internal Lockout on Lack of Synchronism** state. If, on the other hand, the waiting setting is set to **YES**, **Synchronism Waiting Time** state is reached, at which **Synchronism Waiting Time** (adjustable) starts timing.

Activating **SYNC_Rm** before the waiting timer times out generates the activation of **RCLS_CMDm** (**Breaker m Reclose Command**) signal and **Close Waiting Time** state is reached. Otherwise, the recloser switches to **Internal Lockout on Lack of Synchronism** state.

Activating **LO_NO_SYNCm** (**Recloser m Internal Lockout on Lack of Synchronism**) or **LO_CMDm** (**Recloser m Lockout on Command)** generates **Block** or **Slave Recloser Enable** signals as a function of **Slave Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a **Blocked** situation.

Slave Recloser (s) Three-Phase Reclose Time

When this state is reached, the corresponding set time starts timing:

- **First Three-Phase Reclose Time**, when it refers to the first reclose due to a three-phase trip.
- **Second, Third or Fourth Reclose Time**, when it refers to a second, third or fourth retry (as mentioned above, recloses other than the first will always be three-phase).

Similarly than for the single-phase sequence, if a **Recloser Block Command** is issued (activation of **LO_CMDs**) before the timer times out, the recloser resets without reclosing. On the other hand, if the master recloser activates the **Slave Recloser Block Command**, it will go into **Internal Lockout on Master Command** state, which will reset only if the conditions stated in paragraph 3.19.6 are complied with.

If the corresponding **Three-phase Reclose Time** times out, the slave recloser switches to **Waiting for Master Recloser after Three-phase Sequence** state.

3.19.5.c Waiting for Master Recloser. 6IRV-B Models

When the slave recloser **Reclose Time** times out (single-phase or three-phase) the **Waiting for Master Recloser** state is reached (after single-phase or three-phase sequence). In said state, the slave recloser will be waiting for the master recloser to complete the reclose sequence, supervising the following signals:

- **Slave Recloser Enable**: this signal activates when the master recloser successfully completes one reclose (transient fault: **Security time 1** times out without a new trip, see paragraph 3.19.5.e) or when it goes into **Internal Lockout** and **Slave Recloser Enable** is set to **YES**. Activating this signal allows the slave recloser to carry on its reclose sequence, activating directly the **RCLS_CMDs (Breaker s Reclose Command)** signal and switching to **Waiting Reclose** state if the reclose sequence has been single-phase or checking whether synchronism conditions exist if the reclose sequence has been three-phase. In the latter case all comments on the supervision of synchronism in the three-phase reclose sequence for the master recloser are applicable to the slave recloser, swapping variables m and s. In **Synchronism Waiting Time** state, as the breaker associated to the master recloser might already be closed (master recloser in **Waiting for Slave Recloser Closing** state**,** see paragraph 3.19.5.d), a fault can occur (transient, as the master recloser **Security Time 1** has timed out). Thus, during the **Synchronism Waiting Time** state**,** the slave recloser will be supervising the reclose initiate **(RCLS)** signal, in order to start the new three-phase reclose sequence or go into **Internal Lockout on Final Trip** depending on conditions.
- **Slave Recloser Block**: this signal activates when the master recloser goes into internal lockout, the "**Slave Recloser Enable**" setting being set to **NO**. Activating this signal brings the slave recloser into the **Internal Lockout on Master Command** state.
- **Reclose Initiate Signal (RCLS)**: if the fault is permanent, when the breaker associated to the master recloser closes, a new trip will occur, and the **Reclose Initiate** (**RCLS**) signal will activate before **Security Time 1** times out. If the conditions for a new reclose sequence are met (see paragraph 3.19.5.e) both reclosers, master and slave, will switch to the **Three-phase Initiate Time** state, otherwise, both will go into the **Internal Lockout on Final Trip** state.
- **Slave Recloser Block Command (LO_CMDs)**: activating this signal resets the slave recloser without reclosing.

The purpose of the **Waiting for Master Recloser** state is to prevent both breakers from closing and opening on permanent faults, to avoid unnecessary wear.

3.19.5.d Closing Time

- **Automatic Reclose with One Recloser**

After issuing the **Reclose Command**, the recloser switches to the **Waiting for Closing** state, in which setting **Close Command Failure Time** set via the **Command** module (see 3.19) starts timing. If the timer times out before the three poles of the breaker close (deactivation of the **Any Pole Open**, **OR_P_OP** signal, in **6IRV-A** relays or deactivation of **Any Pole Open by Contact State, 52_ORPm_OP**, in **6IRV-B** relays) the **FAIL_CLSm** output (**Close Command Failure**) activates and the recloser switches to **Internal Lockout on Close Failure** state. If during the **Command Failure** time the three breaker poles are closed, the recloser will switch to **Security Time** state.

After issuing the reclose command, the recloser switches to the **Waiting for Closing** state, in which setting **Close Command Failure Time** set via the **Command** module starts timing. During said time the recloser will receive one the following signals:

In both cases, the **RCLS_CMD** output will be deactivated.

- **Automatic Reclose with Two Reclosers. 6IRV-B Model**

Waiting for Master Recloser (m) to Close

After issuing the **Reclose Command**, the master recloser switches to the **Waiting for Closing** state, in which setting **Close Command Failure Time** set via the **Command** module (see 3.19) starts timing. If the timer times out before **52_ORPm_OP** (**Any Breaker m Pole Open by Contact State**) signal deactivates, output **FAIL_CLSm** (**Breaker m Close Command Failure**) activates and the recloser switches to **Internal Lockout on Close Failure** state. If during the **Close Command Failure Time**, the signal **52_ORPm_OP** deactivates, which implies breaker m is closed, the master recloser switches to **Security Time 1**.

In both cases output **RCLS_CMDm** deactivates.

Waiting for Slave Recloser (s) to Close

After issuing the **Reclose Command**, the slave recloser switches to the **Waiting for Closing** state, in which setting **Close Command Failure Time** set via the **Command** module (see 3.19) starts timing. During said time the slave recloser will supervise the following conditions:

- **Master Recloser Block**: this signal activates when the master recloser switches to **Lockout** (internal or on command) while in **Slave Recloser Waiting Time** state, **Slave Enable** being set to **NO**. Activating this signal brings the slave recloser into the **Internal Lockout on Master Command** state.
- **Closing of Three Breaker Poles** (signal **51_ORPs_OP** negated), the master recloser ($\overline{RCLS\_LOm} \times \overline{LO\_CMDm}$) not being blocked: if at the time of closing the breaker associated to the slave recloser the master recloser is not blocked, this must have gone through **Security Time 1** with no trips (activating the **Slave Recloser Enable Signal**), therefore the fault being transient. In this case, as the slave recloser will not have to discern the nature of the fault, it will switch to **Security Time 2** (see 3.19.5.e) state.
- **Closing of Three Breaker Poles** (signal **51_ORPs_OP** negated), the master recloser being blocked (**RCLS_LOm or LO_CMDm**): in this case, the **Slave Recloser Enable Signal** activates when the master recloser reaches a blocked situation. Said blocked situation generates before the master recloser goes through **Security Time 1**. Therefore, the slave recloser switches to **Security Time 1** state, in order to discern whether it is a transient or permanent fault.
- **Reclose Initiate** signal (**RCLS**): if activated, the slave recloser, together with the master recloser, initiate a new three-phase reclose sequence or switch to **Internal Lockout On Definite Trip** (see 3.19.7) depending on conditions.

If **Close Command Failure Time** times out, the signals above not being activated, **FAIL_CLSm** (**Breaker m Close Command Failure**) output activates and the recloser switches to **Internal Lockout on Close Failure** state.

In all cases, the **RCLS_CMDm** output deactivates.

3.19.5.e Security Time

6IRV-A Model

When the Security Time state is achieved, an adjustable **Security Time** timer is started. This setting is common for all the three reclosing sequences. The **Security Time** setting is used to determine whether two consecutive trips correspond to the same fault that has not been successfully cleared, or to two consecutive faults. If the **Security Time** is completed without a trip being initiated, the recloser switches to the recloser **Reset** state, and the reclose attempt is completed.

If a trip occurs (**RCLS** signal activated) before the **Security Time** is completed, the next step in the reclose sequence is determined by the number of **Reclose Attempts** setting. If a trip occurs after the last reclose attempt permitted by this setting, or if the recloser operates in **Dependent Mode** and the first trip has been three-phase (see consultation of **1_TRIP** signal in Figure 3.19.2), the Recloser switches to **Recloser Lockout Due to Definite Trip**. At this point, the reclose sequence ends. If the Recloser has not reached the last permitted reclose attempt, the trip signal that occurs before the **Security Time** is completed will initiate a new reclose attempt. The recloser will then switch to the **Three-Phase Sequence Start** state.

Opening any breaker pole before **Security Time** times out switches the recloser to **Lockout on Open Breaker** state. Also, if a recloser **Block Command** is issued before **Security Time** times out, it switches to **Reset** state.

3.19.5.f Security Time 1. 6IRV-B Model

- **Master Recloser**

When reaching this state, a timer with the setting **Security Time 1**, common for the three recloser sequences, starts timing. Said time is used to discern whether two consecutive trips correspond to the same fault, which has not successfully been cleared, or to two consecutive faults. If **Security Time** times out with no trip occurring, the master recloser switches to **Waiting for Slave Recloser** state.

If a trip occurs (**RCLS** signal activated) before **Security Time 1** times out, the next step depends on whether the number of programmed reclose attempts has been reached or not. If this limit has been reached or if the recloser operates in dependent mode the first trip being three-phase (see consultation of **1_TRIP** signal in figure 3.19.7), both reclosers switch to **Recloser Lockout Due to Definite Trip**, the sequence being completed. Otherwise, a new trip initiates a new close sequence, both reclosers switching to **Three-Phase Sequence Start** state.

Opening any breaker **m** pole before **Security Time 1** times out switches the recloser to **Lockout on Breaker m Open** state. It switches to the **Reset** state if the master recloser is blocked manually before **Security Time 1** times out.

Activating **LO_OPENm** (**Recloser m Internal Lockout on Open Breaker**) or **LO_CMDm** (**Recloser m Lockout on Command)** generates **Block** or **Slave Recloser Enable** (**BLK_SLV** and **PERM_SLV** respectively) signals as a function of **Slave Recloser Enable** setting.

- **Slave Recloser**

The slave recloser will go through **Security Time 1** state only if the master recloser does not, namely when the latter has been blocked before said state is reached, enabling the slave recloser.

The above comments on the master recloser are applicable to the slave recloser (swapping the variables m and s), except with regard to **Block** and **Slave Recloser Enable** signal generation, which are characteristic of the master recloser. On the other hand, if **Security Time** times out with no trips occurring, the slave recloser switches to **Reset** state.

3.19.5.g Slave Close Waiting Time. 6IRV-B Model

At this state, the master recloser waits for the breaker associated to the slave recloser to close, in order for both reclosers switch simultaneously to **Security Time 2** state. In slave close waiting time state, the master recloser supervises the following conditions:

- Deactivation of **52_ORPs_OP (Any Breaker s Pole Open by Contact State)** signal: if this occurs, both reclosers, master and slave, switch to **Security Time 2** state.
- Activation of **Reclose Initiate** signal (**RCLS**): both reclosers initiate a new three-phase reclose sequence or switch to **Recloser Lockout Due to Definite Trip** (see paragraph 3.19.6) depending on conditions.
- Activation of **RCLS_LOs (Recloser s Internal Block)** or **LO_CMDs (Recloser s Block on Command)** signals: this condition switches the master recloser to **Reset** state.

3.19.5.h Slave Close Waiting Time. 6IRV-B Model

If the master recloser goes through **Security Time 1**, and the slave recloser completes its reclose sequence correctly, both reclosers switch to **Security Time 2** state, and this timer starts timing. The purpose of said timer is to allow time to reset the breaker associated to the slave recloser, in case a new trip-reclose sequence occurs the time for the next reclose sequence not being enough for said reset.

During **Security Time 2** both reclosers supervise the following signals:

- **Reclose Start** signal (**RCLS**): its activation will cause both reclosers to initiate a new three-phase reclose sequence or switch to **Recloser Lockout Due to Definite Trip** (see paragraph 3.19.9) depending on conditions.
- **Recloser Lockout** on command signal (**LO_CMDm/s**): its activation will switch the applicable recloser to **Reset** state.
- Opening of any pole of the breaker associated to the recloser signal (**52_ORPm/s_OP**): activation of said signal will switch the applicable recloser to **Internal Lockout on Open Breaker**.

The master recloser will also supervise the activation of **RCLS_LOs (Recloser s Internal Block)** or **LO_CMDs (Recloser s Block on Command)** signals; said condition switches the recloser to **Reset** state.

On the other hand, the slave recloser will also supervise the activation of the signal form the master recloser (**BLK_SLV**), which will switch the recloser to **Internal Lockout on Master Command** state.

If **Security Time 2** times out and none of these signals activate, both reclosers switch to **Reset** state.

3.19.6 Recloser Lockout

- **Automatic Reclose with One Recloser**

The **Recloser Lockout** states correspond to situations in which the Recloser will not initiate its sequence in case of a trip and, consequently, all those produced under these circumstances are definite.

In the previous statement, the Internal Lockout states to which the recloser can arrive once the recloser abandons the reset state as a result of a fault and its corresponding trip are defined. However, there are other circumstances which may result in the internal lockout of the recloser and this is the opening of the breaker not associated with a fault. Under these circumstances, the recloser will change to the **Recloser Lockout Due to Open Breaker** state, remaining unable to carry out the closing.

The Recloser will remain in any of the Internal Lockout states reached until it detects the closing of the breaker. When this situation is detected, the Recloser will abandon the **Internal Lockout** state reached and will change to the **Security Time after an External Closing** state. On entering this state, the count of the **Security Time after an External Closing** setting commences. If the count ends without any trip having been produced (from the equipment or external), the Recloser will change to Reset state. If, on the other hand, a trip is produced before the time ends, the Recloser will change to the Internal **Blocking Due to Close onto a Fault** state and the trip will be definite, without subsequent reclosing.

- **Automatic Reclose with Two Reclosers. 6IRV-B Model**

To reset a recloser, master or slave, reaching an **Recloser Lockout** state, apart from the controlled breaker to close, the other recloser must be in **Recloser Lockout** or **Reset** state. If this situation is detected, the applicable recloser will reset from **lockout** switching to **Security Time on External Closing** state. At this state, **Security Time on External Closing** timer starts timing. If the timer times out with no trips occurring (by own or external relay), the recloser switches to **Reset** state. If, otherwise, a trip occurs before the timer times out, the recloser switches to **Recloser Lockout on Switch onto Fault (LO_COF**) state and the trip will be final, with no later reclose.

Any lockout of the master recloser will activate one of the **Block** or **Slave Recloser Enable** (**BLK_SLV** and **PERM_SLV** respectively) signals as a function of **Slave Recloser Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

3.19.7 Recloser Block Command (Manual or External)

- **6IRV-A Model**

The recloser is provided with two types of blocking commands which take it to the **Block Command** state: **Manual Command** and **External Command**.

The **Manual** and **External Blocking Commands** are produced through the activation of the **INBLK_MAN** (**Recloser Manual Block Command**) and **INBLK_EXT** (**Recloser External Block**) logic inputs, respectively. The objective of the **INBLK_MAN** logic input is to receive signals originating from the HMI or communications (in local or remote mode), while the **INBLK_EXT** logic input is for the purpose of receiving external signals, which will arrive through the digital inputs of the equipment.

Manual Blocking Command is always by pulse; entering into the **Block Command** state will occur with an activation pulse from the **INBLK_MAN** (**Recloser Manual Block Command**), while the exiting of this state requires a complementary unblocking command, which will be issued by an activation pulse of the **IN_UNBLK_MAN** (**Recloser Manual Unblock Command**) input or **IN_UNBLK_EXT** (**Recloser External Unblock Command**) input, provided that the **External Blocking Type** setting is in Pulse.

External Blocking Command may be a pulse or level, according to the **External Blocking Type** setting. When this setting is in **Pulse**, the entry into **Block Command** state will occur with an activation pulse of the **INBLK_EXT** (**Recloser External Block**) input, while the output of this state will be produced with an activation pulse of the **IN_UNBLK_EXT** (**External Unblocking**) or **IN_UNBLK_MAN** (**Manual Unblocking**) inputs. However, if the **External Blocking Type** setting is **Level**, the blocking as well as the unblocking of the Recloser will be produced through the **INBLK_EXT** input. If this input is at **1**, the Recloser will be blocked; if it is at **0**, it will be unblocked. In this case, while the **INBLK_EXT** input is activated, the state of the **IN_UNBLK_EXT** and **IN_UNBLK_MAN** inputs will not be considered; even if these inputs are at **1**, the Recloser will continue to be blocked.

If the Recloser is in a reclose sequence, it will be stopped on receiving the **Block Command**, changing to the **Reset** state. In this state, no reclosing attempt will be made after tripping, which would be, in all cases, definite, generating the **Recloser Lockout Due to Definite Trip** event.

If with the recloser blocked and in a reset state, an **Unblocking Command** is received and the breaker is open, the Recloser would change to **Recloser Lockout Due to Open Breaker** state from which it leaves on the breaker closing. If, on the other hand, the breaker is closed, the Recloser will remain in the **Reset** state.

- **6IRV-B Model**

Each recloser, master and slave, has two types of block commands, which will switch the reclosers to **Block Command** state: **Manual Command** and **External Command**.

Manual and **External Block** commands occur activating logic inputs **INBLK_MANm/s** (**Recloser m/s Manual Block Command**) and **INBLK_EXT** (**Recloser m/s External Block**) respectively. The function of logic input **INBLK_MANm/s** is to receive signals from the HMI or through communications (in local and remote modes), whereas logic input **INBLK_EXTm/s** has the function of receiving external signals through relay digital inputs.

Manual Block commands are always by pulse; a recloser is switched to **Block Command** state via an activation pulse of **INBLK_MANm/s** (**Recloser m/s Manual Block Command**) input, whereas resetting from this state needs an additional unblock command via activation pulse of **IN_UNBLK_MANm/s** (**Recloser m/s Manual Unblock Command**) input or **IN_UNBLK_EXT** (**Recloser m/s External Unblock**) input, provided **External Blocking Type** is set to **Pulse**. In order for the recloser to reset from **Lockout on Command** state, apart from the applicable unblock command, the other recloser must be in **Reset** or **Recloser Lockout** state.

The **External Block** command can be on pulse or level, as a function of **External Blocking Type** setting. When said setting is set to **Pulse**, switching a recloser to **Block Command** state will be via activation pulse of **INBLK_EXT** (**Recloser External Block**) input, whereas said state will be reset via activation pulse of **IN_UNBLK_EXT** (**External Unblock**) or **IN_UNBLK_MAN** (**Manual Unblock**) inputs, provided the other recloser is in **Reset** or **Recloser Lockout** state. If **External Blocking Type** setting is set to **Level**, both recloser lockout and reset will occur via **INBLK_EXT** input. If said input is set to **1**, the recloser will be blocked; if it is set to **0**, the other recloser being in reset or internal lockout state, it will be unblocked. In this case, the state of **IN_UNBLK_EXT** and **IN_UNBLK_MAN** inputs will not be taken into account while input **INBLK_EXT** remains activated; the recloser remains blocked even if said inputs are set to **1**.

3.19.8 Definite Trip

- **6IRV-A Model**

The Recloser will generate a **Recloser Lockout Due to Definite Trip** (**LO_DT** output) signal when a trip is produced with the **Recloser in Manual Block** or in circumstances such that the Recloser Start Element Activated signal (**RCLS**) is not activated. In this case, the recloser changes to the Recloser **Lockout Due to Definite Trip** state.

Although not expressed in the flow diagrams, each time that the **LO_3PH** (**Recloser Lockout Due to Three-Phase Trip** -**6IRV-A** Model-), **LO_SCF** (**Recloser Lockout Due to Breaker Failure**), **LO_BF** (**Recloser Lockout Due to Close Failure**) and **LO_NO_SYNC** (**Recloser Lockout Due to Synchronism Failure**) signals are activated, the **LO_DT** (**Recloser Lockout Due to Definite Trip**) signal should also be activated.

- **6IRV-B Model**

What has been said for **6IRV-A** relays applies to **6IRV-B** relays, bearing in mind that each recloser will have an associated **Recloser Lockout Due to Definite Trip** signal.

3.19.9 Recloser Not in Service

The Recloser is placed in the Not in Service state whenever the Recloser **Enable** setting is **NO**.

3.19.10 Reclose Counter

- **6IRV-A Model**

There are two counters accessible from the operator interface display, which indicate the number of reclose attempts completed. The counters can be reset from the operator interface. One counter records the number of single-phase reclose attempts, and the second counts the three-phase reclose attempts. For example, when the number of reclose attempts is set to three, and a fault has been successfully cleared after the third trip, the first counter is incremented one count and two counts in the second.

- **6IRV-B Model**

6IRV-B relay reclosers have two shot counters, one for single-phase and one for three-phase reclosing, similar to the ones described for **6IRV-A** relays.

3.19.11 Recloser Settings

Recloser In Service			
Setting	**Range**	**Step**	**By default**
Recloser in service	YES / NO		NO

Recloser Timers			
Setting	**Range**	**Step**	**By default**
First single-phase reclosing attempt delay	0.05 - 300 s	0.01 s	1 s
First three-phase reclosing attempt delay	0.05 - 300 s	0.01 s	0.5 s
Second reclosing attempt delay	0.05 - 300 s	0.01 s	0.5 s
Third reclosing attempt delay	0.05 - 300 s	0.01 s	0.5 s
Fourth reclosing attempt delay	0.05 - 300 s	0.01 s	0.5 s

Sequence Control Time			
Setting	**Range**	**Step**	**By default**
Sequence check (start) time	0.07 - 0.60 s	0.01 s	0.2 s
Security time (6IRV-A)	0.05 - 300 s	0.01 s	10 s
Security time 1 (6IRV-B)	0.05 - 300 s	0.01 s	10 s
Security time 2 (6IRV-B)	0.05 - 300 s	0.01 s	0.5 s
Manual close reset time	0.05 - 300 s	0.01 s	5 s
Synchronism wait time	0.05 - 300 s	0.01 s	5 s

Sequence Control			
Setting	**Range**	**Step**	**By default**
Reclosing Mode	1P Mode 3P Mode 1P / 3P Mode Dependent Mode Selection by DI		1P Mode
Number of reclose attempts (6IRV-A)	1 - 3		3
Number of reclose attempts (6IRV-B)	1 - 4		4
Number of reclosers in operation (6IRV-B)	1, 2, Selection by DI		1
Master recloser (6IRV-B)	1, 2, Selection by DI		1
Slave recloser (6IRV-B)	YES / NO		YES
External blocking	Level / Pulse		Level

Recloser Start Mask			
Setting	**In Display**	**Range**	**By default**
Open phase detector	OPEN PHASE	YES / NO	NO
Phase time overcurrent (51-1)	TOC PH1	YES / NO	NO
Phase time overcurrent (51-2)	TOC PH2	YES / NO	NO
Phase time overcurrent (51-3)	TOC PH3	YES / NO	NO
Phase instantaneous overcurrent (50-1)	IOC PH1	YES / NO	NO
Phase instantaneous overcurrent (50-2)	IOC PH2	YES / NO	NO
Phase instantaneous overcurrent (50-3)	IOC PH3	YES / NO	NO
Ground time overcurrent (51N-1)	TOC GND1	YES / NO	NO
Ground time overcurrent (51N-2)	TOC GND2	YES / NO	NO
Ground time overcurrent (51N-3)	TOC GND3	YES / NO	NO
Ground instantaneous overcurrent (50N-1)	IOC GND1	YES / NO	NO
Ground instantaneous overcurrent (50N-2)	IOC GND2	YES / NO	NO
Ground instantaneous overcurrent (50N-3)	IOC GND3	YES / NO	NO
Negative Sequence time overcurrent (51Q-1)	TOC NEG SEQ1	YES / NO	NO
Negative Sequence time overcurrent (51Q-2)	TOC NEG SEQ2	YES / NO	NO
Negative Sequence time overcurrent (51Q-3)	TOC NEG SEQ3	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-1)	IOC NEG SEQ1	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-2)	IOC NEG SEQ2	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-3)	IOC NEG SEQ3	YES / NO	NO
External trip	Ext Trip	YES / NO	NO
Programmable trip	Prog Trip	YES / NO	NO

Synchronism Check Supervision*			
Setting	**Range**	**Step**	**By default**
Synchronism Check supervision enable			
1st reclosing supervision	YES / NO		NO
2nd reclosing supervision	YES / NO		NO
3rd reclosing supervision	YES / NO		NO
4th reclosing supervision	YES / NO		NO
Synchronism Check wait enable			
1st reclosing wait time	YES / NO		NO
2nd reclosing wait time	YES / NO		NO
3rd reclosing wait time	YES / NO		NO
4th reclosing wait time	YES / NO		NO

(*) Separate for each recloser in 6IRV-B relays

- **Recloser: HMI Access. 6IRV-A Model**

0 - CONFIGURATION	0 - GENERAL	**0 - IN SERVICE**
1 - OPERATIONS	1 - PROTECTION	**1 - RECLOSER TIMERS**
2 - CHANGE SETTINGS	**2 - RECLOSER**	**2 - SEQ CONTROL TIMER**
3 - INFORMATION	...	**3 - SEQUENCE CONTROL**
		4 - RECLOSER INIT MASK
		5 - SYNCROCHECK SUPERV.

Recloser Timers

0 - IN SERVICE	
1 - RECLOSER TIMERS	**0 - 1ST 1PH RECL ATTEMPT**
2 - SEQ CONTROL TIMER	**1 - 1ST 3PH RECL ATTEMPT**
3 - SEQUENCE CONTROL	**2 - 2ND RECLOS ATTEMPT**
4 - RECLOSER INIT MASK	**3 - 3RD RECL. ATTEMPT**

Sequence Control Timers

0 - IN SERVICE	**0 - START TIME**
1 - RECLOSER TIMERS	**1 - SECURITY TIME**
2 - SEQ CONTROL TIMER	**2 - MC RESET TIME**
3 - SEQUENCE CONTROL	**3 - SYNC WAIT TIME**
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

Sequence Control

0 - IN SERVICE	**0 - RECLOSING MODE**
1 - RECLOSER TIMERS	**1 - RECLOSE ATTEMPTS**
2 - SEQ CONTROL TIMER	**2 - EXTERNAL BLOCKING**
3 - SEQUENCE CONTROL	
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

Synchronism Check Supervision

0 - IN SERVICE	**0 - SYNC. SUPERV. ENABLE**
1 - RECLOSER TIMERS	**1 - SYNC WAIT ENABLE**
2 - SEQ CONTROL TIME	
3 - SEQUENCE CONTROL	
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

- **Recloser: HMI access. 6IRV-B Model**

0 - CONFIGURATION	0 - GENERAL	**0 - IN SERVICE**
1 - OPERATIONS	1 - PROTECTION	**1 - RECLOSERS NUMBER**
2 - CHANGE SETTINGS	**2 - RECLOSER**	**2 - MASTER RECLOSER**
3 - INFORMATION	...	**3 - SLAVE PERMISSION**
		4 - RECLOSER TIMERS
		5 - SEQ CONTROL TIMER
		6 - SEQUENCE CONTROL
		7 - RECLOSER INIT MASK

Recloser Timers

0 - IN SERVICE	
1 - RECLOSERS NUMBER	
2 - MASTER RECLOSER	
3 - SLAVE PERMISSION	**0 - 1ST 1PH RECL ATTEMPT**
4 - RECLOSER TIMERS	**1 - 1ST 3PH RECL ATTEMPT**
5 - SEQ CONTROL TIMER	**2 - 2ND RECLOS ATTEMPT**
6 - SEQUENCE CONTROL	**3 - 3RD RECL. ATTEMPT**
7 - RECLOSER INIT MASK	**4 - 4TH RECL. ATTEMPT**

Sequence Control Timers

0 - IN SERVICE	
1 - RECLOSERS NUMBER	
2 - MASTER RECLOSER	
3 - SLAVE PERMISSION	**0 - START TIME**
4 - RECLOSER TIMERS	**1 - SECURITY TIME**
5 - SEQ CONTROL TIMER	**2 - SECURITY TIME 2**
6 - SEQUENCE CONTROL	**3 - MC RESET TIME**
7 - RECLOSER INIT MASK	**4 - SYNC WAIT TIME**

Sequence Control

0 - IN SERVICE	
1 - RECLOSERS NUMBER	
2 - MASTER RECLOSER	
3 - SLAVE PERMISSION	
4 - RECLOSER TIMERS	
5 - SEQ CONTROL TIMER	**0 - RECLOSING MODE**
6 - SEQUENCE CONTROL	**1 - RECLOSE ATTEMPTS**
7 - RECLOSER INIT MASK	**2 - EXTERNAL BLOCKING**

3.19.12 Digital Inputs and Events of the Recloser

Table 3.19-1: Digital Inputs and Events of the Recloser

Name	Description	Function
IN_EXT_A	A pole external trip input	Activation of this input indicates the existence of an A pole trip of the breaker generated by an external protection.
IN_EXT_B	B pole external trip input	Activation of this input indicates the existence of an B pole trip of the breaker generated by an external protection.
IN_EXT_C	C pole external trip input	Activation of this input indicates the existence of an C pole trip of the breaker generated by an external protection.
IN_EXT_3PH	Three-phase external trip input	Activation of this input indicates the existence of a three-phase trip of the breaker generated by an external protection.
IN_EXT	External trip input	Activation of this input indicates the existence of a trip of the breaker generated by an external protection.
INBLK_MAN	Recloser manual block command (6IRV-A)	An activation pulse of this input sends the recloser to the Block Command state.
IN_UNBLK_MAN	Recloser manual unblock command (6IRV-A)	An activation pulse of this input removes the recloser from the Block Command state (provided that the External Blocking Type setting is not at level and the BE input is active).

Table 3.19-1: Digital Inputs and Events of the Recloser		
Name	**Description**	**Function**
INBLK_MAN1	Recloser 1 manual block command (6IRV-B)	An activation pulse of this input sends the recloser 1 to the Block Command state.
IN_UNBLK_MAN1	Recloser 1 manual unblock command (6IRV-B)	An activation pulse of this input removes the recloser 1 from the Block Command state (provided that the External Blocking Type setting is not at level and the BE input is active).
INBLK_MAN2	Recloser 2 manual block command (6IRV-B)	An activation pulse of this input sends the recloser 2 to the Block Command state.
IN_UNBLK_MAN2	Recloser 2 manual unblock command (6IRV-B)	An activation pulse of this input removes the recloser 2 from the Block Command state (provided that the External Blocking Type setting is not at level and the BE input is active).
INBLK_EXT	Recloser external block command (6IRV-A)	An activation pulse of this input sends the recloser to the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_UNBLK_EXT	Recloser external unblock command (6IRV-A)	An activation pulse of this input removes the recloser from the Block Command state (provided that the External Blocking Type setting is at Pulse).
INBLK_EXT1	Recloser 1 external block command (6IRV-B)	An activation pulse of this input sends the recloser 1 to the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_UNBLK_EXT1	Recloser 1 external unblock command (6IRV-B)	An activation pulse of this input removes the recloser 1 from the Block Command state (provided that the External Blocking Type setting is at Pulse).

Table 3.19-1: Digital Inputs and Events of the Recloser		
Name	**Description**	**Function**
INBLK_EXT2	Recloser 2 external block command (6IRV-B)	An activation pulse of this input sends the recloser 2 to the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_UNBLK_EXT2	Recloser 2 external unblock command (6IRV-B)	An activation pulse of this input removes the recloser 2 from the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_BLKRCLS	Reclose Initiate Block Input	Activating said input prevents reclose initiate.
RST_NUMREC	Shot counter reset command (6IRV-A)	Said input resets the two breaker shot counters (single-phase and three-phase)
RST_NUMREC1	Shot counter reset command breaker 1 (6IRV-B)	Said input resets the two breaker 1 shot counters (single-phase and three-phase)
RST_NUMREC2	Shot counter reset command breaker 2 (6IRV-B)	Said input resets the two breaker 2 shot counters (single-phase and three-phase)
ENBL_REC	Recloser Enable Input	Activating this input puts the automatic recloser in operation. They can be assigned to level digital inputs or commands from the communications protocol or the HMI. Default value is "1".
IN_1P	1P Mode Input	Together with input IN_3P, it defines the reclose mode, provided Reclose Mode is set to ED Selection.
IN_3P	3P Mode Input	Together with input IN_1P, it defines the reclose mode, provided Reclose Mode is set to ED Selection.
IN_2REC	2 Reclosers in Operation Input (6IRV-B)	Allows selecting the number of reclosers in operation, provided Number of Reclosers in Operation is set to ED selection
IN_1MAS	Master Recloser 1 Input (6IRV-B)	Allows selecting the master recloser provided Master recloser is set to ED selection

3.19.13 Digital Outputs and Events of the Recloser

Table 3.19-2: Digital Outputs and Events of the Recloser		
Name	**Description**	**Function**
RCLS	Recloser start	Recloser start.
RECLOSING	Reclose sequence in progress	Reclose sequence in progress.
RECLOSING1	Reclose 1 sequence in progress (6IRV-B)	Reclose 1 sequence in progress.
RECLOSING2	Reclose 2 sequence in progress (6IRV-B)	Reclose 2 sequence in progress.
RCLS_CMD	Reclose command (6IRV-A)	Reclose command.
RCLS_CMD1	Reclose command breaker 1 (6IRV-B)	Reclose command breaker 1.
RCLS_CMD2	Reclose command breaker 2 (6IRV-B)	Reclose command breaker 2.
RCLS_LO	Recloser lockout (6IRV-A)	LO_NO_SYNC + LO_DT + LO_CLSF + LO_COF + LO_BF + LO_3PH + LO_OPEN
RCLS_LO1	Recloser 1 lockout (6IRV-B)	LO_NO_SYNC1 + LO_DT1 + LO_CLSF1 + LO_COF1 + LO_BF1 + LO_3PH1 + LO_OPEN1 + LO_MAS1
RCLS_LO2	Recloser 2 lockout (6IRV-B)	LO_NO_SYNC1 + LO_DT1 + LO_CLSF1 + LO_COF1 + LO_BF1 + LO_3PH1 + LO_OPEN1 + LO_MAS1
LO_NO_SYNC	Recloser lockout due to lack of synchronism (6IRV-A)	
LO_NO_SYNC1	Recloser 1 lockout due to lack of synchronism (6IRV-B)	
LO_NO_SYNC2	Recloser 2 lockout due to lack of synchronism (6IRV-B)	
LO_DT	Recloser lockout due to definite trip (6IRV-A)	
LO_DT1	Recloser 1 lockout due to definite trip (6IRV-B)	
LO_DT2	Recloser 2 lockout due to definite trip (6IRV-B)	
LO_BF	Recloser lockout due to breaker close failure (6IRV-A)	
LO_BF1	Recloser 1 lockout due to breaker close failure (6IRV-B)	
LO_BF2	Recloser 2 lockout due to breaker close failure (6IRV-B)	
LO_COF	Recloser lockout due to close-onto-a-fault (6IRV-A)	
LO_COF1	Recloser 1 lockout due to close-onto-a-fault (6IRV-B)	
LO_COF2	Recloser 2 lockout due to close-onto-a-fault (6IRV-B)	

Table 3.19-2: Digital Outputs and Events of the Recloser		
Name	**Description**	**Function**
LO_BF	Recloser lockout due to breaker failure (6IRV-A)	
LO_BF1	Recloser 1 lockout due to breaker failure (6IRV-B)	
LO_BF2	Recloser 2 lockout due to breaker failure (6IRV-B)	
LO_3PH	Recloser lockout due to three-phase trip (6IRV-A)	
LO_3PH1	Recloser 1 lockout due to three-phase trip (6IRV-B)	
LO_3PH2	Recloser 2 lockout due to three-phase trip (6IRV-B)	
LO_OPEN	Recloser lockout due to open breaker (6IRV-A)	
LO_OPEN1	Recloser 1 lockout due to open breaker (6IRV-B)	
LO_OPEN2	Recloser 2 lockout due to open breaker (6IRV-B)	
LO_CMD	Recloser lockout command (6IRV-A)	
LO_CMD1	Recloser 1 lockout command (6IRV-B)	
LO_CMD2	Recloser 2 lockout command (6IRV-B)	
LO_MAS1	Recloser 1 lockout master command (6IRV-B)	
LO_MAS2	Recloser 2 lockout master command (6IRV-B)	
RESET_C_RNG	Recloser counters reset (6IRV-A)	
RESET_C_RNG1	Recloser breaker 1 counters reset (6IRV-B)	
RESET_C_RNG2	Recloser breaker 2 counters reset (6IRV-B)	
BLK_CMD	Recloser Block Command (6IRV-A)	Recloser block command generated through manual or external block command
BLK_CMD1	Recloser 1 Block Command (6IRV-B)	Recloser 1 block command generated through manual or external block command
BLK_CMD2	Recloser 2 Block Command (6IRV-B)	Recloser 2 block command generated through manual or external block command

Table 3.19-2: Digital Outputs and Events of the Recloser		
Name	**Description**	**Function**
UNBLK_CMD	Recloser Unblock Command (6IRV-A)	Recloser unblock command generated through manual or external block command
UNBLK_CMD1	Recloser 1 Unblock Command (6IRV-B)	Recloser 1 unblock command generated through manual or external block command
UNBLK_CMD2	Recloser 2 Unblock Command (6IRV-B)	Recloser 2 unblock command generated through manual or external block command
ACT_EXTR	External trip activation (6IRV-A)	Trip indication of any pole of the breaker by external protection.
ACT_EXTR_3PH	External three-phase trip activation	Trip indication of the three poles of the breaker by external protection.
REC_ENBLD	Recloser Enabled	Automatic reclose function enabled or disabled state signal.
PERM_SLV	Slave Recloser Enable (6IRV-B)	Enable signal for the slave recloser to resume the reclose sequence.
BLK_SLV	Slave recloser block (6IRV-B)	Signal for the slave recloser to finalize the reclose sequence switching to lockout.
1P	1P Mode Active	Active 1P reclose mode signal.
3P	3P Mode Active	Active 3P reclose mode signal.
1P3P	1P/3P Mode Active	Active 1P/3P reclose mode signal.
DEP	DEP Mode Active	Active dependent reclose mode signal.
1REC	1 Recloser in Operation (6IRV-B)	Single recloser in operation signal.
2REC	2 Recloser in Operation (6IRV-B)	Two reclosers in operation signal.
1MAS	Master Recloser 1 (6IRV-B)	Signal states recloser 1 is master.
2MAS	Master Recloser 2 (6IRV-B)	Signal states recloser 2 is master.
RCLS1_INSERV	Recloser 1 in Operation (6IRV-B)	Signal states recloser 1 is in operation.
RCLS2_INSERV	Recloser 2 in Operation (6IRV-B)	Signal states recloser 2 is in operation.

Table 3.19-2: Digital Outputs and Events of the Recloser		
Name	**Description**	**Function**
RCLS1_STANDBY	Recloser 1 reset (6IRV-B)	Signal states recloser 1 is reset.
RCLS2_STANDBY	Recloser 2 reset (6IRV-B)	Signal states recloser 2 is reset.
IN_EXT_A	A pole external trip input	The same as for the Digital Inputs.
IN_EXT_B	B pole external trip input	
IN_EXT_C	C pole external trip input	
IN_EXT_3PH	Three-phase external trip input	
IN_EXT	External trip input	
INBLK_MAN	Recloser manual block command (6IRV-A)	
IN_UNBLK_MAN	Recloser manual unblock command (6IRV-A)	
INBLK_MAN1	Recloser 1 manual block command (6IRV-B)	
IN_UNBLK_MAN1	Recloser 1 manual unblock command (6IRV-B)	
INBLK_MAN2	Recloser 2 manual block command (6IRV-B)	
IN_UNBLK_MAN2	Recloser 2 manual unblock command (6IRV-B)	
INBLK_EXT	Recloser external block command (6IRV-A)	
IN_UNBLK_EXT	Recloser external unblock command (6IRV-A)	
INBLK_EXT1	Recloser 1 external block command (6IRV-B)	
IN_UNBLK_EXT1	Recloser 1 external unblock command (6IRV-B)	
INBLK_EXT2	Recloser 2 external block command (6IRV-B)	
IN_UNBLK_EXT2	Recloser 2 external unblock command (6IRV-B)	
IN_BLKRCLS	Reclose Initiate Block Input	
RST_NUMREC	Shot counter reset command (6IRV-A)	
RST_NUMREC1	Shot counter reset command breaker 1 (6IRV-B)	
RST_NUMREC2	Shot counter reset command breaker 2 (6IRV-B)	
ENBL_REC	Recloser Enable Input	
IN_1P	1P Mode Input	
IN_3P	3P Mode Input	
IN_2REC	2 Reclosers in Operation Input (6IRV-B)	
IN_1MAS	Master Recloser 1 Input (6IRV-B)	

3.19.14 Recloser Parameters

Table 3.19-3: Recloser Parameters		
Name	**Description**	**Function**
C REENG1	Breaker 1 actual reclose sequence (6IRV-B)	
C REENG2	Breaker 2 actual reclose sequence (6IRV-B)	
REE MONO	Single-phase shot counter (6IRV-A)	
REE TRIF	Three-phase shot counter (6IRV-A)	
REE MONO 1	Breaker 1 single-phase shot counter (6IRV-B)	
REE MONO 2	Breaker 2 single-phase shot counter (6IRV-B)	
REE TRIF 1	Breaker 1 three-phase shot counter (6IRV-B)	
REE TRIF 2	Breaker 2 three-phase shot counter (6IRV-B)	

3.19.15 Recloser Test

3.19.15.a 6IRV-A Model

For testing the recloser function, the following is important:

- After a manual closing, the **Security Time after a Manual Close** should be awaited. If this time is not allowed to expire before generating the trip, the Recloser will become blocked.
- In order to start the reclose sequence, the protection should detect that the breaker is open and that current does not circulate through the phases before concluding the **Sequence Start Time** (setting situated in the **Recloser** - **Sequence Control Time**).
- In order that the recloser carries out the entire sequence up to the definite trip, the trips should be carried out with a time interval between them shorter than the adjusted **Security Time**.
- The trip and reclose masks should be considered.

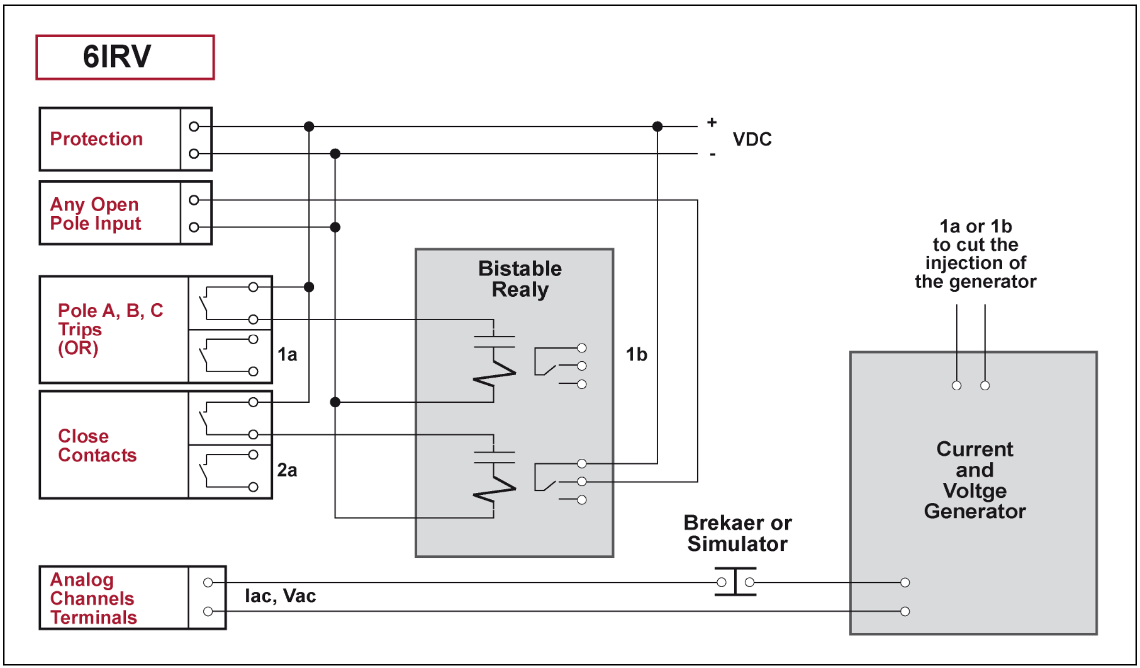


Figure 3.19.17:Connection Diagram for the Recloser Test.

Figure 3.19.17 shows how to perform the Recloser test. If the current generator does not cut off the injection before the sequence check times out, the test can be performed either by opening the current circuit (with the breaker itself or by simulating it), or by causing an instantaneous unit trip with a simple pulse. This may be enough for the instantaneous unit to operate and, at the same time, to cease detecting current before the sequence check times out.

In case that three bistables are available to carry out the test, a trip should be wired to each bistable (A pole, B pole, C pole). Similarly, we will obtain one output from each bistable, which we will wire to the **Open A Pole**, **Open B Pole** and **Open C Pole** inputs (instead of wiring the three to **Any Open Pole**).

Once we have the scheme of Figure 3.19.17 prepared, the following auxiliary outputs will be configured in the manner indicated:

Table 3.19-4:Output Configuration for the Recloser Test

Output	Description of Logic Signal
AUX5	Recloser lockout
AUX6	Recloser lockout due to lack of synchronism
AUX7	Recloser lockout due to definite trip
AUX8	Recloser lockout due to breaker close failure
AUX9	Recloser lockout due to close-onto-a-fault
AUX10	Recloser lockout due to breaker failure
AUX11	Recloser lockout due to three-phase trip
AUX12	Recloser lockout due to open breaker
AUX13	Recloser sequence in progress
AUX14	Recloser blocked
AUX15	Reclose signal activation

During the entire recloser test, an attempt will be made for there to be synchronism conditions in order that this is not internally lockout due to lack of synchronism.

The breaker will close, waiting longer than the reset time after external closing to continue.

Disable all the auxiliary units except one overcurrent unit and adjust all the bits of the **Zone Trip Mask** to **NO**, except those corresponding to said overcurrent unit.

- **1P Mode**

Two tests should be performed, corresponding to a first single-phase trip and to a first three-phase trip.

First Single-Phase Trip

A single-phase trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the single-phase reclose time) and a short activation of the output **AUX15**.

A new trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal, prior to the expiration of the **Security Time**. The following contacts should be closed: the **Recloser Lockout** (**AUX5**), the **Recloser Lockout Due to Definite Trip** (**AUX7**) and the **Recloser Lockout Due to Three-Phase Trip** (**AUX11**). The **Recloser Sequence in Progress** contact should be open (**AUX13** deactivated). Once this state has been reached, no subsequent reclose signal should be produced.

Close the breaker. The **Recloser Lockout** (**AUX5**), the **Recloser Lockout Due to Definite Trip** (**AUX7**) and **Recloser Lockout Due to Three-Phase Trip** (**AUX11**) outputs should deactivate after **Security Time**.

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit.

A trip will occur. Produce a trip, closing the **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Three-Phase Trip** (**AUX11**) contacts.

The breaker will close. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Three-Phase Trip** (**AUX11**) outputs should deactivate after Security Time.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **0**.

- **3P Mode**

Set the unit to **3P Mode**. Trips in this mode should always be three-phase. A single test should be performed, corresponding to a first three-phase trip.

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the Reclose Time) and a short activation of the output **AUX15**.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Security Time expires, the current will be reapplied, producing a trip. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state is reached, a subsequent reclosing will not take place.

The breaker will close. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate after the Security Time.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **3**. After viewing the display, reset the counters.

- **1P / 3P Mode**

Set the unit to **1P / 3P Mode**. Two tests should be performed, corresponding to a first single-phase trip and to a first three-phase trip. After each trip, the fault report should contain information regarding the conditions surrounding the trip.

First Single-Phase Trip

A single-phase trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the single-phase reclose time) and a short activation of the output **AUX15**.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Security Time expires, the current will be reapplied. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state is reached, a subsequent reclosing will not take place.

The breaker will close. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should open after the Security Time.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **1** and the number of three-phase reclose attempts equals **2**. After viewing the display, reset the counters.

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the first three-phase reclose time) and a short activation of the output **AUX15**.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

The current will be reapplied before the Security Time expires. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state reached, a subsequent reclosing will not take place.

The breaker will close. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate once the Security Time has expired.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **3**. After viewing, reset the counters.

- **Dependent Mode**

Set the unit to the **Dependent Mode**. Two tests should be performed, corresponding to a first single-phase trip and to a first three-phase trip. After each trip, the fault report should contain information regarding the conditions surrounding the trip.

First Single-Phase Trip

A single-phase trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the single-phase reclose time) and a short activation of the output **AUX15**.

Before the Security Time expires, the current a current higher than the adjusted value for the Overcurrent Unit will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Security Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

The current will be reapplied before the Security Time expires. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state reached, a subsequent reclosing will not take place.

The breaker will close. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate once the Security Time has expired.

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the first three-phase reclose time) and a short activation of the output **AUX15**.

Before the Security Time expires, the current will be reapplied. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close. **The Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state reached, a subsequent reclosing will not take place.

The breaker will close. **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate 3 seconds later.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **1**. Reset the counters.

3.19.15.b 6IRV-B Model

6IRV-B relay automatic reclose function consists of two reclosers coordinated with each other. When only one recloser is enabled (number of reclosers in operation setting = 1), checks will be similar to the checks described for **6IRV-A** relays. When two reclosers are enabled, the coordination with each other shall be checked. The check, in this case, must be made with six flip-flops, which will simulate all poles of breakers 1 and 2 (hard wire to the applicable inputs). A Pole trip signals will be hard wired to the two flip-flops simulating the A poles of breakers 1 and 2. B and C pole trip signals will be hard wired in like manner.

Synchronism through both breakers is recommended during automatic reclose check to prevent one breaker switching to **Recloser Lockout Due to Lack of Synchronism**.

Breakers will be closed, waiting for the **Security Time after External Closing** to time out to continue.

All auxiliary elements other than one overcurrent unit will be disabled and all **Zone Mask** bits will be set to **NO**, except the bit corresponding to that overcurrent unit.

- **1P Mode**

Two checks will be made, corresponding to one first single-phase trip and one first three-phase trip.

First Single-phase Trip

A single-phase trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal. The following events should occur:

The following events will happen:

- Trip and activation of **Sequence in progress** signal for both reclosers (master and slave).
- Master reclose after **Single-phase** reclose time times out (slave recloser will be in **Waiting for Master Recloser** state).

A single-phase trip is produced again by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal, before **Security Time 1** times out. Following signals for both reclosers, master and slave, will activate: **Recloser Lockout**, **Recloser Lockout Due to Definite Trip** and **Recloser Lockout Due to Three-phase Trip**, deactivating **Sequence in progress** signal**.** No further retries will take place in said states.

Both breakers will close, and **Recloser Lockout, Recloser Lockout Due to Definite Trip** and **Recloser Lockout Due to Three-phase Trip** signals deactivate when the Security Time after a Manual Close times out.

Shot counters of both reclosers will be checked, the number of master recloser single-phase shots must be **1**, the number of slave recloser single-phase shots must be **0** and the number of three-phase shots for both reclosers must be **0**. Then, the counters will be reset.

The check can be repeated injecting the fault when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser shot counter that must now be **1**.

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit.

A trip will occur and **Internal Block** and **Recloser Lockout Due to Three-phase Trip** signals of both reclosers will activate.

Both breakers will close, and **Internal Block** and **Recloser Lockout Due to Three-phase Trip** signals of both reclosers will deactivate when the Security Time after a Manual Close times out.

Shot counters of both reclosers will be checked, the Number of single-phase shots must be **0** and the Number of three-phase shots must be **0** for both reclosers.

- **3P Mode**

The **Reclose Mode** must be set to **3P Mode**. Shots on this reclose mode will always be three-phase, so that only one check is made, corresponding to a first three-phase trip (single-phase fault).

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the Reclose Time times out (slave recloser will be in **Waiting for Master Recloser** state).

Before the **Security Time 1** expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the **Security Time 1** expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the **Security Time 1** expires, the current will be reapplied, producing a trip and, on expiration of the time of the 4th reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals activate, and **Sequence in progress** of both reclosers deactivate. Later reclose shots will not occur from this state.

Both breakers will close, and **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals of both reclosers will deactivate when the Security Time after a Manual Close times out.

Shot counters will be checked, the number of **Single-Phase** shots must be **0** for both reclosers, the number of **Three-Phase** shots must be **4** for the master recloser and the number of **Three-Phase** shots must be **0** for the slave recloser. Then, shot counters reset.

The above check can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser three-phase shot counter that must now be 4.

- **1P/3P Mode**

The **Reclose mode** must be set to **1P/3P Mode**. Two checks will be made, corresponding to a first single-phase trip and a first three-phase trip. Fault reports will be collected after each check.

First single-phase trip

A single-phase trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal. The following events should occur:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the **Single-phase Reclose Time** times out (slave recloser will be in **Waiting for Master Recloser** state).

Before the Security Time 1 expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the Security Time 1 expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the **Security Time 1** expires, the current will be reapplied, producing a trip and, on expiration of the time of the 4th reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals activate, and **Sequence in progress** of both reclosers deactivate. Later reclose shots will not occur from this state.

Both breakers will close, and **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals deactivate when the Security Time after a Manual Close times out.

Shot counters of both reclosers will be checked, the number of master recloser **Single-phase shots** must be **1**, the number of master recloser **Three-phase shots** must be **3** and the number of slave recloser **Three-phase and single-phase shots** must be **0**. Then, the counters will be reset.

The check above can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser single-phase and three-phase shot counters that must now be **1** and **3** respectively.

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the **First Three-phase Reclose** time times out (slave recloser will be in waiting for master recloser state).

Before the Security Time 1 expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the Security Time 1 expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the **Security Time 1** expires, the current will be reapplied, producing a trip and, on expiration of the time of the 4th reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals activate**,** and **Sequence in progress** of both reclosers deactivate. Later reclose shots will not occur from this state.

Both breakers will close, and **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals deactivate when the Security Time after a Manual Close times out.

Shot counters will be checked, the number of **Single-phase shots** must be **0** for both reclosers, the number of **Three-phase shots** must be **4** for the master recloser and the number of **Three-phase shots** must be **0** for the slave recloser. Then, shot counters reset.

The above check can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser three-phase shot counter that must now be 4.

- **Dependent Mode**

Reclose Mode will be set to **Dependent Mode**. Two checks will be made, corresponding to a first single-phase trip and a first three-phase trip. Fault reports will be collected after each check.

First single-phase trip

A single-phase trip is produced by the **External Trip Activation** (**ACT_EXTR**) signal, being deactivated the **Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal. The following events should occur:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the **Single-phase Reclose Time** times out (slave recloser will be in **Waiting for Master Recloser** state).

Before the Security Time 1 expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the Security Time 1 expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Before the **Security Time 1** expires, the current will be reapplied, producing a trip and, on expiration of the time of the 4th reclosing attempt, new master reclose. **Sequence in progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals activate**,** and **Sequence in progress** of both reclosers deactivate. Later reclose shots will not occur from this state.

Both breakers will close, and **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals deactivate when the Security Time after a Manual Close times out.

Shot counters will be checked, the number of master recloser **Single-phase shots** must be **1**, the number of master recloser **Three-phase shots** must be **3** and the number of slave recloser **Three-phase and single-phase shots** must be **0**. Then, the counters will be reset.

The check above can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser single-phase and three-phase shot counters that must now be **1** and **3** respectively**.**

First Three-Phase Trip

Apply a current higher than the adjusted value for the Overcurrent Unit. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the first **Three-phase Reclose Time** times out (slave recloser will be in **Waiting for Master Recloser** state).

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals activate**,** and **Sequence in Progress** of both reclosers will deactivate. No further retries will take place in said states.

Both breakers will close, and **Recloser Lockout** and **Recloser Lockout due to Definite Trip** signals deactivate when the Security Time after a Manual Close times out.

Shot counters will be checked, the number of **Single-phase shots** must be **0** for both reclosers, the number of master recloser **Three-phase shots** must be **1** and the number of slave recloser **Three-phase shots** must be **0**. Then, shot counters reset.

The above check can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser three-phase shot counter that must now be **1**.

3.20 Command Logic

3.20.1 Introduction

The **6IRV** IED presents a command logic in charge of generating the open command outputs of each pole of the breaker (**OPEN_A**, **OPEN_B** and **OPEN_C**), in addition to the open outputs (**OPEN**) and three-phase open (**OPEN_3PH**), from the trip commands (originating from the Tripping Logic) and manual open (**Manual Open Command** input: **IN_OPEN_CMD**). Similarly, the command module is in charge of generating the close output of the breaker (**CLOSE**) from the reclose (**RCLS_CMD**) and manual close (**Manual Close Command** input: **IN_CLOSE_MAN**) commands.

On the other hand, the command module allows to generate the **Open Command Failure** signals of each pole of the breaker (**FAIL_OPEN_A**, **FAIL_OPEN_B** and **FAIL_OPEN_C**) and **Close Command Failure** (**FAIL_CLS**), from the previously-mentioned open / close outputs

The following functions exist within the Command Logic group: **Trip Seal-in Enable**, **Breaker Opening / Closing Failure Time Delay**, **Close supervision by Synchronism Check** and **Pickup Report**.

3.20.2 Opening Command

3.20.2.a Opening Command Logic. 6IRV-A Model

The opening command generation logic is shown in Figures 3.20.1 and 3.20.2.

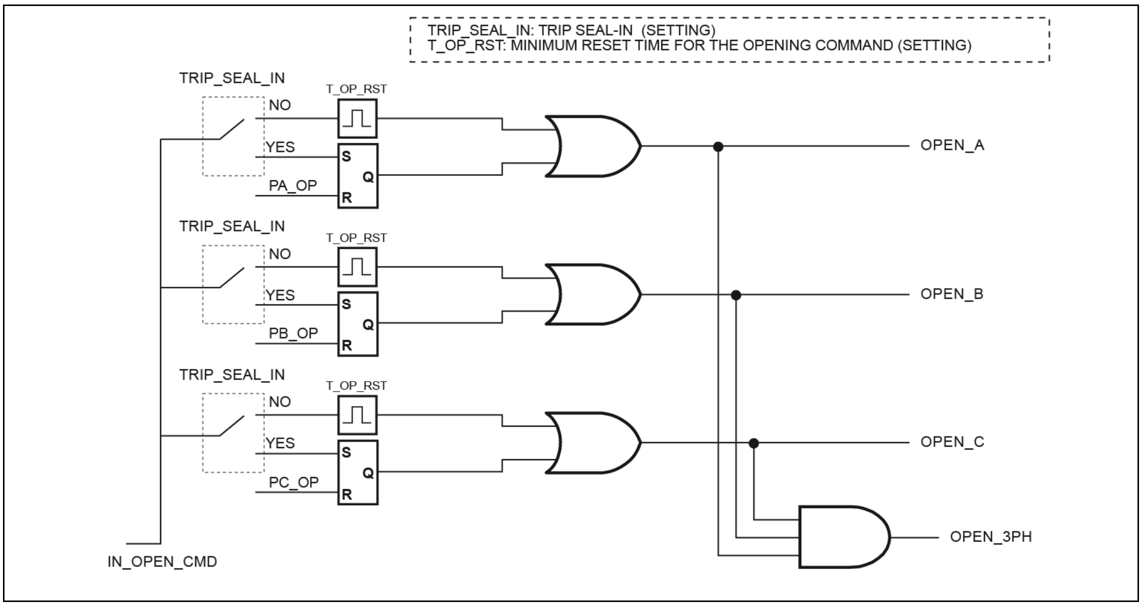


Figure 3.20.1: Logic Diagram of Generation of Opening Commands from a Manual Command (6IRV-A).

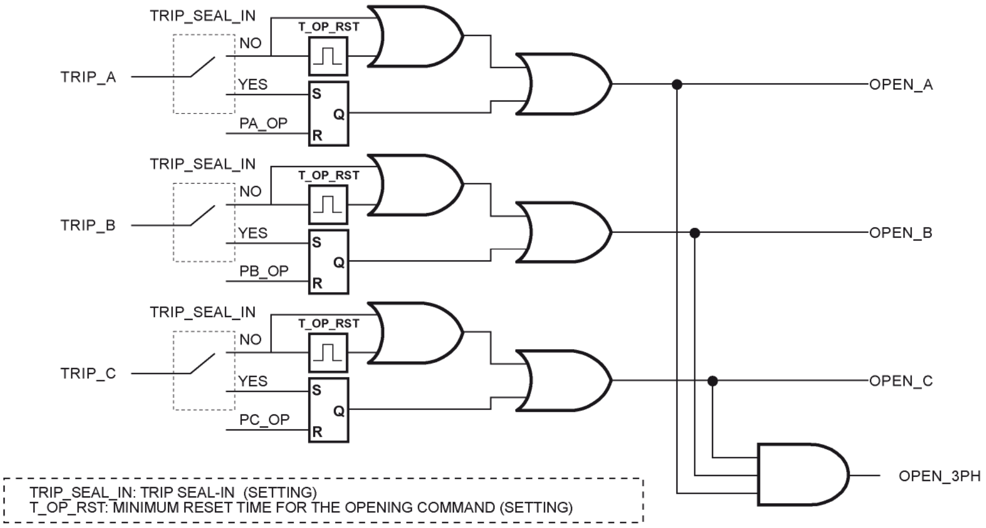


Figure 3.20.2: Logic Diagram of Generation of Opening Commands from Trip Commands (6IRV-A).

The trip seal-in function is enabled by providing the **Seal-In Enable** setting with the **YES** value. Under these circumstances, the opening command over a pole of the breaker (**OPEN_A**, **OPEN_B** and **OPEN_C**) will be kept activated as long as the opening of this is not detected (**PA_OP**, **PB_OP** and **PC_OP** open pole detector outputs). The objective of this setting is to ensure that the break contacts of the relay do not cut the current of the trip circuit of the breaker poles, given that this operation will be carried out by the corresponding 52/a auxiliary contact of the breaker. The relay contacts may be damaged on cutting the trip circuit current, since this current (basically inductive and of a high value) tends to exceed the rated break characteristics of these contacts.

Although the **NO** value is assigned to the **Seal-in Enable** setting, if the opening command originates from trip outputs, it should be considered that these outputs remain activated until the supervision units are reset, which already produces a seal. On the other hand, in the command logic, for manual operations as well as trip commands, a time is guaranteed for the opening command, configurable according to the **T_OP_RST** setting (**Minimum Reset Time from the Open Command**):

- If the activation of the opening command is preceded by a trip signal that is deactivated before the **T_OP_RST** time, the opening command will last during the set time. If the activation of the trip signal lasts longer than the **T_OP_RST** setting, the opening command will stay until the trip condition clears.
- If the activation of the opening command precedes a manual opening command, its duration is always a pulse defined by the **T_OP_RST** time.

Only if the trip **Seal-in Enable** setting is set at **YES** will the opening command be maintained for the necessary time until the breaker open is shown.

Once the opening command of a pole of the breaker is generated, if the **Opening Command Failure Time** setting elapses without detecting the open status of the pole, the **Opening Command Failure** output of this pole (**FAIL_OPEN_A**, **FAIL_OPEN_B** and **FAIL_OPEN_C**) is activated, in addition to the **Opening Command Failure** (**FAIL_OPEN**) generic output.

3.20.2.b Opening Command Logic. 6IRV-B Model

6IRV-B relays can operate two breakers, so they incorporate open command generation logic similar to the logic described in the paragraph above for each breaker. Said logics are shown in figures 3.20.3, 3.20.4, 3.20.5 and 3.20.6.

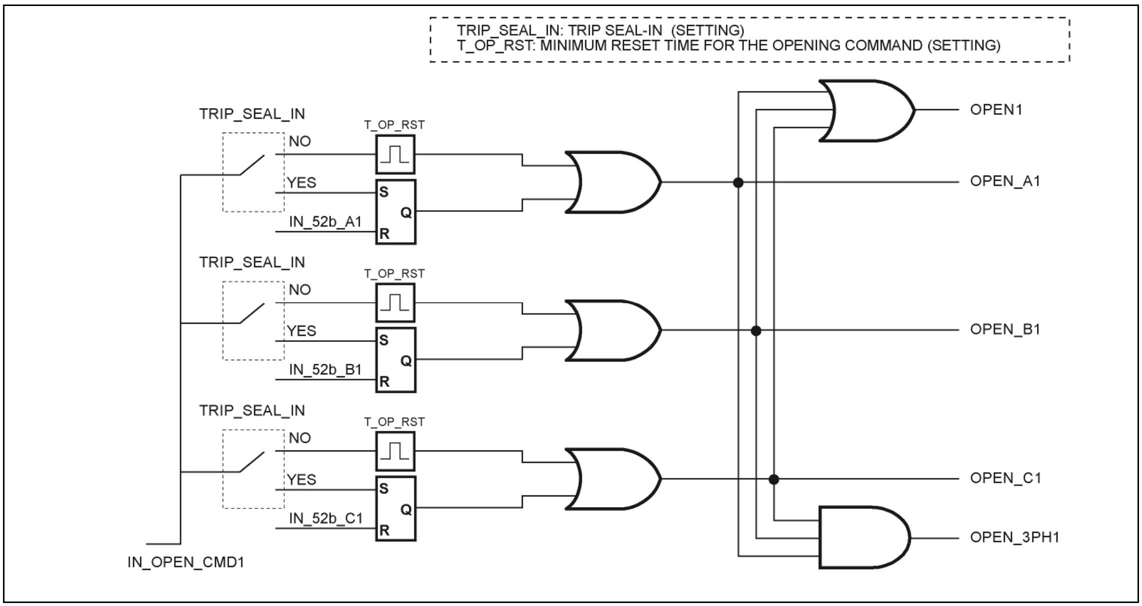


Figure 3.20.3: Breaker 1 Open Command Generation Logic Diagram from Manual Command (6IRV-B).

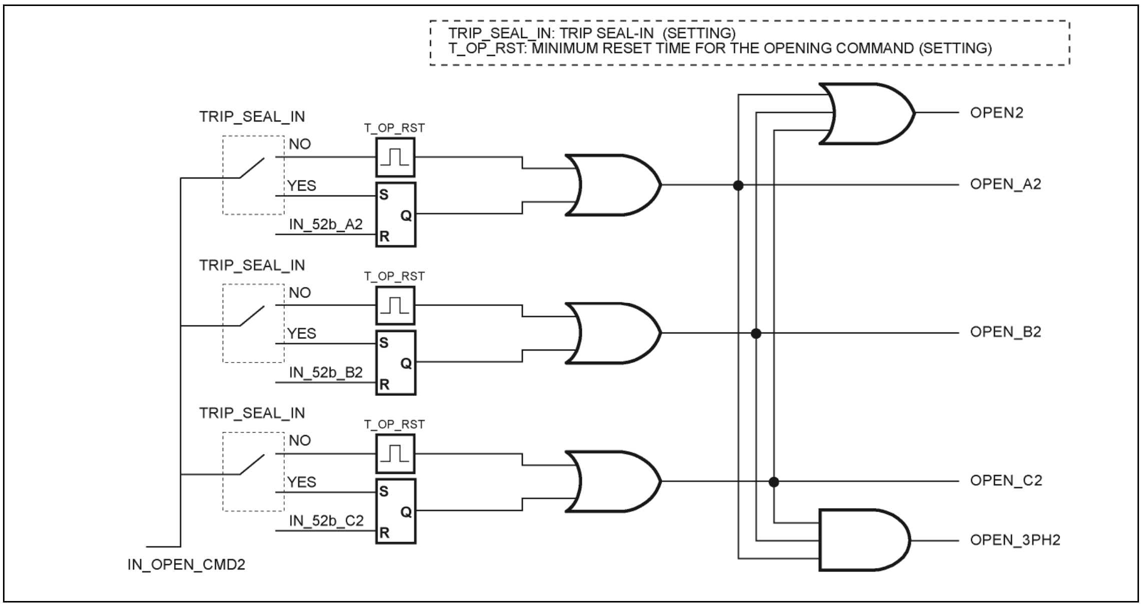


Figure 3.20.4: Breaker 2 Open Command Generation Logic Diagram from Manual Command (6IRV-B).

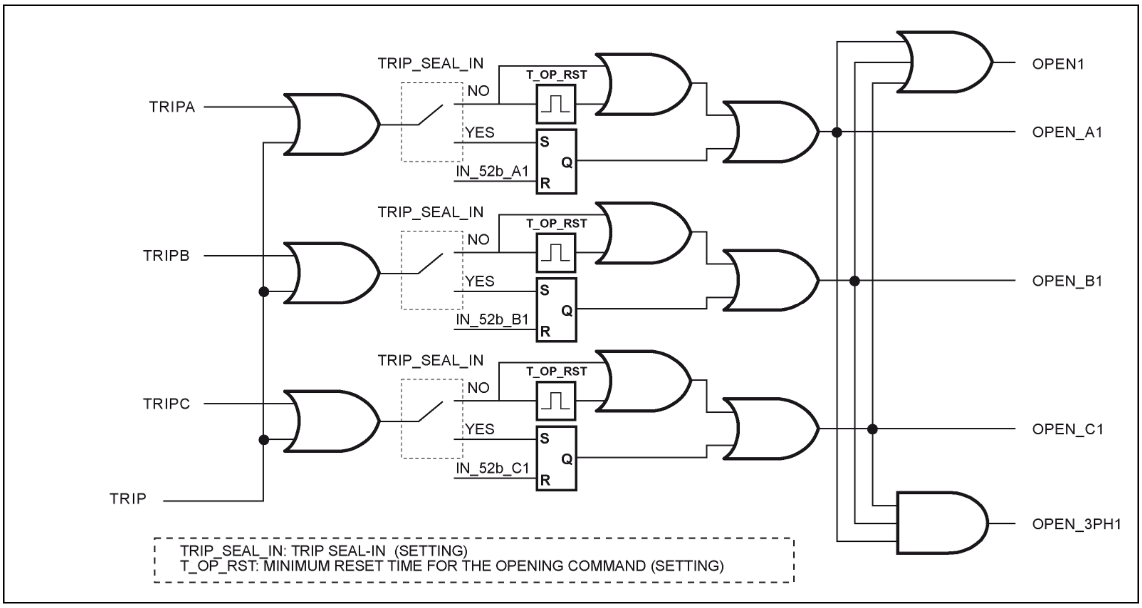


Figure 3.20.5: Breaker 1 Open Command Generation Logic Diagram from Trip Command (6IRV-B).

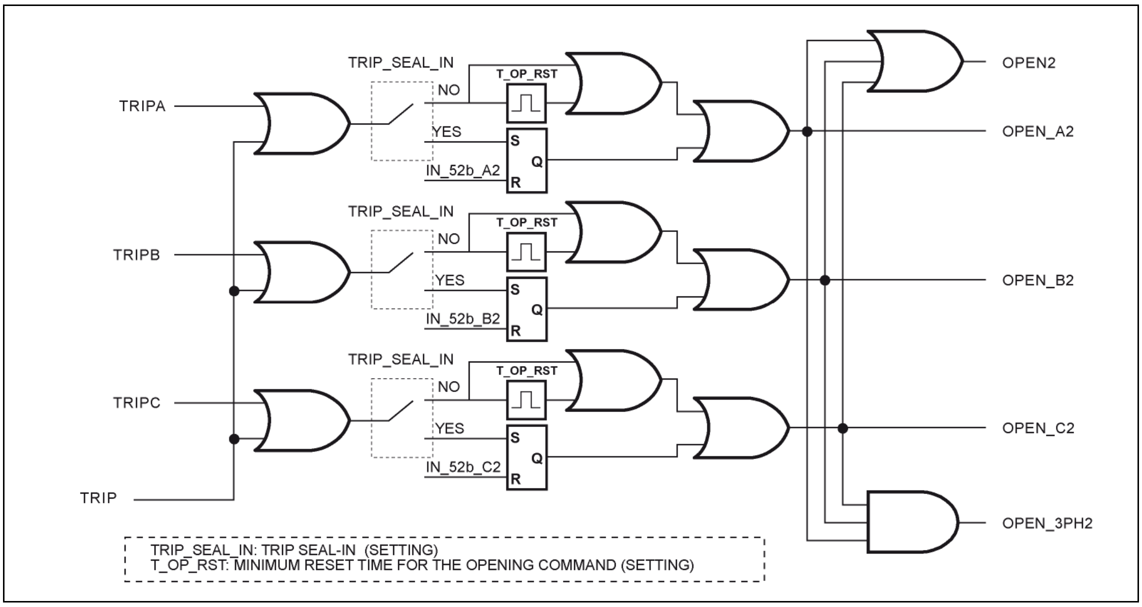


Figure 3.20.6: Breaker 2 Open Command Generation Logic Diagram from Trip Command (6IRV-B).

In **6IRV-B** relays, the signals **OPEN, OPEN_3PH, OPEN_A, OPEN_B and OPEN_C** are obtained as an OR of signals **OPEN1** y **OPEN2**, **OPEN_3PH1** and **OPEN_3PH2 OPEN_A1** and **OPEN_A2**, **OPEN_B1** and **OPEN_B2**, **OPEN_C1** and **OPEN_C2** respectively.

3.20.3 Closing Commands

3.20.3.a 6IRV-A Model

The **Close** output (**CLOSE**) will be generated by the **Reclose Command** (**RCLS_CMD**) or by the **Manual Close Command** (**IN_CLOSE_MAN**). The latter close command may be supervised by the existence of synchronism. For this, it is necessary that the **Close Supervision Due to Synchronism** setting (**SUP_C_SINC**) be set at **YES**.

The **Close Command** output will be disabled on the following conditions:

- Close Block input activation.
- Open Command output activation.
- All breaker poles closed.

Once the close command of the breaker is generated, if the **Closing Command Failure Time** setting elapses without detecting the closing of the breaker (no pole open: **OR_P_OP** at zero) the **Closing Command Failure** (**FAIL_CLS**) output is activated.

The **Close** output will be maintained until it is detected that the breaker has closed or until the **Close Command Failure** is issued.

The **Close** output will remain active at least the **Minimum Reset Time for Closing** (**T_CL_RST** setting). In addition, if the breaker fails to close, this time could be prolonged until the **Closing Command Failure** is given (provided that this time is longer than the **T_CL_RST** setting).

In case of protection trips, the **Opening Command** will remain as long as the reason for which this originated continues, even if the **Opening Failure Time** is exceeded.

3.20.3.b 6IRV-B Model

6IRV-B relays can operate two breakers and thus they include a close command generation logic similar to the logic explained in the paragraph above for each breaker.

In **6IRV-B** relays, the signal to close the breaker used to generate **Breaker n (n=1,2) Close Command** output will be the negation of **52_ORPn_OP** (**Any breaker n pole open by contact indication**).

6IRV-B relay control module incorporates a shot counter for each breaker. Said shot counters can be reset through a digital input.

3.20.3.c Close Synchronism Check

The **Close Command** output (**CLOSEm**) will be generated by **Manual Close Command** (**IN_CLOSE_MANm**). This close command can be supervised through whether synchronism exists or not*. To this end, the **Synchronism Close Supervision** (**SUP_C_SINCm**) setting must be set to **YES**.

(*) For models 6IRV-A ** - ** 2 * or higher, only the synchronism indicated by unit 1 of the synchronism unit itself will be supervised.**

3.20.4 Command Logic Settings

Command Logic Settings			
Setting	**Range**	**Step**	**By default**
Trip seal-in enable	YES / NO		NO
Minimum reset time for the opening command	0.1 - 5 s	0.1 s	0.2 s
Breaker opening failure time delay	0.02 - 5 s	0.01 s	0.02 s
Minimum reset time for the closing command	0 - 5 s	0.1 s	0.2 s
Breaker closing failure time delay	0.02 - 5 s	0.01 s	0.02 s
Breaker closing Synchrocheck Supervision (6IRV-A)	YES / NO		NO
Breaker 1 closing Synchrocheck Supervision (6IRV-B)	YES / NO		NO
Breaker 2 closing Synchrocheck Supervision (6IRV-B)	YES / NO		NO
Pickup report	YES / NO		NO

- **Command Logic Settings: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP SEAL-IN**
1 - OPERATIONS	1 - PROTECTION	**1 - MIN OPENING RES T**
2 - CHANGE SETTINGS	2 - RECLOSER	**2 - FAIL TO OPEN TIME**
3 - INFORMATION	**3 - LOGIC**	**3 - MIN CLOSING RES T**
	...	**4 - FAIL TO CLOSE TIME**
		5 - PICK UP REPORT
		6 - SYNCR. SUPERVISION

6IRV-B MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP SEAL-IN**
1 - OPERATIONS	1 - PROTECTION	**1 - MIN OPENING RES T**
2 - CHANGE SETTINGS	2 - RECLOSER	**2 - FAIL TO OPEN TIME**
3 - INFORMATION	**3 - LOGIC**	**3 - MIN CLOSING RES T**
	...	**4 - FAIL TO CLOSE TIME**
		5 - PICK UP REPORT
		6 - SYNC. SUPERVISION1
		7 - SYNC. SUPERVISION2

3.20.5 Digital Inputs and Events of the Command Logic Module

Table 3.20-1: Digital Inputs and Events of the Command Logic Module

Name	Description	Function
IN_BLK_CLS	Breaker close blocking input (6IRV-A)	Its activation blocks close output.
IN_OPEN_CMD	Manual opening command (6IRV-A)	Its activation generates manual open and close commands, respectively; these can be assigned to HMI, to communications, to digital inputs or to any signal of the programmable logic. Its application is directed toward being assigned to COMMANDS.
IN_CLOSE_CMD	Manual closing command (6IRV-A)	
IN_BLK_CLS1	Breaker 1 close blocking input (6IRV-B)	Its activation blocks close output of the breaker 1.
IN_BLK_CLS2	Breaker 2 close blocking input (6IRV-B)	Its activation blocks close output of the breaker 2.
IN_OPEN_CMD1	Breaker 1 manual opening command (6IRV-B)	Its activation generates manual open and close commands, respectively; these can be assigned to HMI, to communications, to digital inputs or to any signal of the programmable logic. Its application is directed toward being assigned to COMMANDS.
IN_CLOSE_CMD1	Breaker 1 manual closing command (6IRV-B)	
IN_OPEN_CMD2	Breaker 2 manual opening command (6IRV-B)	Its activation generates manual open and close commands, respectively; these can be assigned to HMI, to communications, to digital inputs or to any signal of the programmable logic. Its application is directed toward being assigned to COMMANDS.
IN_CLOSE_CMD2	Breaker 2 manual closing command (6IRV-B)	
ORD_REP_CAPER1_A	Breaker 1 A pole open counter reset input (6IRV-B)	Activating this input resets breaker 1 A pole open counter
ORD_REP_CAPER1_B	Breaker 1 B pole open counter reset input (6IRV-B)	Activating this input resets breaker 1 B pole open counter
ORD_REP_CAPER1_C	Breaker 1 C pole open counter reset input (6IRV-B)	Activating this input resets breaker 1 C pole open counter

Table 3.20-1: Digital Inputs and Events of the Command Logic Module		
Name	**Description**	**Function**
ORD_REP_CAPER2_A	Breaker 2 A pole open counter reset input (6IRV-B)	Activating this input resets breaker 2 A pole open counter
ORD_REP_CAPER2_B	Breaker 2 B pole open counter reset input (6IRV-B)	Activating this input resets breaker 2 B pole open counter
ORD_REP_CAPER2_C	Breaker 2 C pole open counter reset input (6IRV-B)	Activating this input resets breaker 2 C pole open counter
ORD_REP_CCIER1	Breaker 1 reclose shot counter reset input (6IRV-B)	Activating this input resets breaker 1 reclose shot counter
ORD_REP_CCIER2	Breaker 2 reclose shot counter reset input (6IRV-B)	Activating this input resets breaker 2 reclose shot counter

3.20.6 Digital Outputs and Events of the Command Logic Module

Table 3.20-2: Digital Outputs and Events of the Command Logic Module		
Name	**Description**	**Function**
OPEN	Open command (6IRV-A)	Open.
OPEN_A	A pole open command (6IRV-A)	A pole open output of the breaker.
OPEN_B	B pole open command (6IRV-A)	B pole open output of the breaker.
OPEN_C	C pole open command (6IRV-A)	C pole open output of the breaker.
OPEN_3PH	Three-phase open command (6IRV-A)	Three-phase open output of the breaker.
CLOSE	Close (6IRV-A)	Close output of the breaker.
FAIL_OPEN	Open command failure (6IRV-A)	Activated from when the open or close commands are issued, the adjusted times elapse, but these are not carried out.
FAIL_OPEN_A	A pole open command failure (6IRV-A)	
FAIL_OPEN_B	B pole open command failure (6IRV-A)	
FAIL_OPEN_C	C pole open command failure (6IRV-A)	
FAIL_CLS	Close command failure (6IRV-A)	
OPEN1	Breaker 1 open command (6IRV-B)	Breaker 1 open output.
OPEN_A1	Breaker 1 A pole open command (6IRV-B)	Breaker 1 A pole open output.
OPEN_B1	Breaker 1 B pole open command (6IRV-B	Breaker 1 B pole open output.
OPEN_C1	Breaker 1 C pole open command (6IRV-B)	Breaker 1 C pole open output.
OPEN_3PH1	Breaker 1 three-phase open command (6IRV-B)	Breaker 1 three-phase open output.
CLOSE1	Breaker 1 reclose command (6IRV-B)	Breaker 1 reclose output.

Table 3.20-2: Digital Outputs and Events of the Command Logic Module

Name	Description	Function
FAIL_OPEN1	Breaker 1 open command failure (6IRV-B)	These signals activate when breaker 1 open and reclose commands are not executed before the timer settings time out.
FAIL_OPEN_A1	Breaker 1 A pole open command failure (6IRV-B)	
FAIL_OPEN_B1	Breaker 1 B pole open command failure (6IRV-B)	
FAIL_OPEN_C1	Breaker 1 C pole open command failure (6IRV-B)	
FAIL_CLS1	Breaker 1 reclose command failure (6IRV-B)	
OPEN2	Breaker 2 open command (6IRV-B)	Breaker 2 open output.
OPEN_A2	Breaker 2 A pole open command (6IRV-B)	Breaker 2 A pole open output.
OPEN_B2	Breaker 2 B pole open command (6IRV-B)	Breaker 2 B pole open output.
OPEN_C2	Breaker 2 C pole open command (6IRV-B)	Breaker 2 C pole open output.
OPEN_3PH2	Breaker 2 three-phase open command (6IRV-B)	Breaker 2 three-phase open output.
CLOSE2	Breaker 2 reclose command (6IRV-B)	Breaker 2 reclose output.
FAIL_OPEN2	Breaker 2 open command failure (6IRV-B)	These signals activate when breaker 2 open and reclose commands are not executed before the timer settings time out.
FAIL_OPEN_A2	Breaker 2 A pole open command failure (6IRV-B)	
FAIL_OPEN_B2	Breaker 2 B pole open command failure (6IRV-B)	
FAIL_OPEN_C2	Breaker 2 C pole open command failure (6IRV-B)	
FAIL_CLS2	Breaker 2 reclose command failure (6IRV-B)	
IN_BLK_CLS	Breaker close block input (6IRV-A)	The same as for the Digital Inputs.
IN_OPEN_CMD	Manual open command (6IRV-A)	The same as for the Digital Inputs.
IN_CLOSE_CMD	Manual close command (6IRV-A)	
IN_BLK_CLS1	Breaker 1 close block input (6IRV-B)	The same as for the Digital Inputs.
IN_BLK_CLS2	Breaker 2 close block input (6IRV-B)	
IN_OPEN_CMD1	Breaker 1 manual open command (6IRV-B)	The same as for the Digital Inputs.
IN_CLOSE_CMD1	Breaker 1 manual close command (6IRV-B)	
IN_OPEN_CMD2	Breaker 2 manual open command (6IRV-B)	The same as for the Digital Inputs.
IN_CLOSE_CMD2	Breaker 2 manual close command (6IRV-B)	
ENBL_3PH_1	Breaker 1 three-phase open enable input (6IRV-B)	The same as for the Digital Inputs.
ENBL_3PH_2	Breaker 2 three-phase open enable input (6IRV-B)	
ORD_REP_CAPER1_A	Breaker 1 A pole open counter reset input (6IRV-B)	The same as for the Digital Inputs.
ORD_REP_CAPER1_B	Breaker 1 B pole open counter reset input (6IRV-B)	
ORD_REP_CAPER1_C	Breaker 1 C pole open counter reset input (6IRV-B)	
ORD_REP_CAPER2_A	Breaker 2 A pole open counter reset input (6IRV-B)	The same as for the Digital Inputs.
ORD_REP_CAPER2_B	Breaker 2 B pole open counter reset input (6IRV-B)	
ORD_REP_CAPER2_C	Breaker 2 C pole open counter reset input (6IRV-B)	

3.20.7 Control Logic Parameters

Table 3.20-3:Control Logic Parameters		
Name	**Description**	**Units**
NAPERINT1_A	Number of breaker 1 A pole openings (6IRV-B)	
NAPERINT1_B	Number of breaker 1 B pole openings (6IRV-B)	
NAPERINT1_C	Number of breaker 1 C pole openings (6IRV-B)	
NAPERINT2_A	Number of breaker 2 A pole openings (6IRV-B)	
NAPERINT2_B	Number of breaker 2 B pole openings (6IRV-B)	
NAPERINT2_C	Number of breaker 2 C pole openings (6IRV-B)	
NCIERREINT1	Number of breaker 1 reclose shots (6IRV-B)	
NCIERREINT2	Number of breaker 2 reclose shots (6IRV-B)	
NAPER_A	Number of breaker A pole openings (6IRV-A)	
NAPER_B	Number of breaker B pole openings (6IRV-A)	
NAPER_C	Number of breaker C pole openings (6IRV-A)	
NCIERRE	Number of breaker 1 reclose shots (6IRV-A)	

3.21 Configuration Settings

3.21.1 Introduction

The Configuration settings group has the following groups of settings: Nominal Values, Passwords, Communications, Operations, Date and Time, Contrast and HMI Configuration settings.

3.21.2 Nominal Values (Operation Mode)

The **Nominal Values** settings serve to select the rated operating values for both currents and voltages. The selectable parameters are:

- Nominal phase current.
- Nominal ground current (also affecting ground polarization current in models that include it).
- Nominal polarization current.
- Voltage: the rated value of the voltage is set in phase-phase value. This is the reference for all settings expressed in times or % of the nominal voltage. It is applied to the phase voltages as well as to the synchronism voltage.
- Nominal frequency: permits choosing the rated frequency of the network, independently of whether or not the system for adapting to the frequency can later adapt to the changes that occur in this magnitude.

After modifying any of these settings, which are only accessible from the HMI display, the relay restarts the same way as if its power supply were turned off and then back on; no setting or information is lost.

3.21.3 Passwords

The Passwords option allows changing the access password for the options: **Configuration**, **Operations** and **Settings**.

Selecting the Configuration option allows varying the access password for the options of the **Configuration** group. Likewise, it is possible to configure different passwords for the **Operations** options and for modifying **Settings**.

3.21.4 Communications

See section 3.32 of Communications.

3.21.5 Date and Time

Selecting **Date and Time** from the **Configuration** menu provides access to this setting to configure the date and the time.

3.21.6 Contrast Setting

This setting serves to modify the contrast value of the display (higher value = greater contrast).

3.21.7 Configuration Settings

Nominal Values			
Setting	**Range**	**Step**	**By default**
Nominal IABC	1 A / 5 A		5 A
Nominal IN (6IRV-A)	1 A / 5 A		5 A
Nominal Ipol	1 A / 5 A		5 A
Nominal Voltage	50 - 230 V		110 V
Nominal Frequency	50 Hz / 60 Hz		50 Hz

Passwords
The factory-specified access password (full access) is 2140. Nevertheless, you can change the password to access the following options with the keypad: **Configuration**, **Operations** and **Settings**.

Communications
See section 3.32

Date and Time			
Setting	**Range**	**Step**	**By Default**
Local Time Zone	GMT+(0, 1, 2, 3, 3:30, 4, 4:30, 5, 5:30, 5:45, 6, 6:30, 7, 8, 9, 9:30, 10 ,11, 12) GMT-(1, 2, 3, 3:30, 4, 5, 6, 7, 8, 9, 9:30, 10 ,11)		GMT+01:00
Summer Time / Winter Time Change Enable	YES / NO		NO
Summer Begin Time	0 - 23 Hours	1	2
Summer Begin Day Type	0 = Specific day 1 = First Sunday of the month 2 = Second Sunday of the month 3 = Third Sunday of the month 4 = Fourth Sunday of the month 5 = Last Sunday of the month		Last Sunday of the month
Summer Begin Day	1 - 31	1	1
Summer Begin Month	January, February, March, ...	1	March
Winter Begin Time	0 - 23 Hours	1	3
Winter Begin Day Type	0 = Specific day 1 = First Sunday of the month 2 = Second Sunday of the month 3 = Third Sunday of the month 4 = Fourth Sunday of the month 5 = Last Sunday of the month		Last Sunday of the month
Winter Begin Day	1 - 31	1	1
Winter Begin Month	January, February, March, ...	1	March

Contrast
Adjustable from keyboard

Graphic HMI Configuration
See 1.4

- **Configuration Settings: HMI Access**

MOD. 6IRV-A

0 - CONFIGURATION	**0 - NOMINAL VALUES**	**0 - NOMINAL IABC**
1 - OPERATIONS	1 - PASSWORDS	**1 - NOMINAL IG**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - NOMINAL IPOL**
3 - INFORMATION	3 - TIME AND DATE	**3 - NOMINAL VABC**
	4 - CONTRAST	**4 - NOMINAL FREQ.**
	5 - HMI DIAGRAM CONF.	

MOD. 6IRV-B

0 - CONFIGURATION	**0 - NOMINAL VALUES**	**0 - NOMINAL IABC**
1 - OPERATIONS	1 - PASSWORDS	**1 - NOMINAL IPOL**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - NOMINAL VABC**
3 - INFORMATION	3 - TIME AND DATE	**3 - NOMINAL FREQ.**
	4 - CONTRAST	
	5 - HMI DIAGRAM CONF.	

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - CONFIGURATION**
1 - OPERATIONS	**1 - PASSWORDS**	**1 - OPERATIONS**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - SETTINGS**
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	
	5 - HMI DIAGRAM CONF.	

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - PORTS**
1 - OPERATIONS	1 - PASSWORDS	**1 - PROTOCOLS**
2 - CHANGE SETTINGS	**2 - COMMUNICATIONS**	
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	
	5 - HMI DIAGRAM CONF.	

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - TIME AND DATE**
1 - OPERATIONS	1 - PASSWORDS	**1 - LOCAL TIME ZONE**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - SUMMER/WINTER ENAB**
3 - INFORMATION	**3 - TIME AND DATE**	**3 - SUMMER START HOUR**
	4 - CONTRAST	**4 - TYPE OF SUMMER DAY**
	5 - HMI DIAGRAM CONF.	**5 - SUMMER STARTINGDAY**
		6 - SUMMER START MONTH
		7 - WINTER START HOUR
		8 - TYPE OF WINTER DAY
		9 - WINTER STARTINGDAY
		10 - WINTER START MONTH

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - T RETURN**
1 - OPERATIONS	1 - PASSWORDS	**1 - CONTRAST**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	
	5 - HMI DIAGRAM CONF.	

3.22 General Settings

3.22.1 Introduction

The following settings are included within the General Settings group: Unit in Service, Transformer Ratios, Phase Sequence and Neutral Voltage Origin.

3.22.2 Unit in Service

IED enabled (**YES**) allows every function in the system to be executed (as programmed in the corresponding settings).

IED disabled (**NO**) only leaves the system metering functional. Metering values will be displayed in the HMI and via communications.

3.22.2.a Digital Outputs and Events (Unit in Service)

Table 3.22-1: Digital Outputs and Events (Unit in Service)

Name	Description	Function
PROT_INSRV	Protection in service	Indicates that the IED is working with all the functions available.

3.22.3 Transformer Ratios

Transformer ratio defines how analog values are displayed on the protection display. If transformer ratio is set to 1, secondary values are displayed. If, on the other hand, the transformer ratio corresponding to analog input adapter transformer is selected, primary values are displayed. Settable turn ratios are:

- Phase, ground and polarization ground.
- Phase, synchronism and ground voltage.

In all cases, all overcurrent and overvoltage protection element settings are referred to secondary values. Programmable logic analog settings could refer both to secondary and primary values.

3.22.4 Transducer Inputs

Depending on the relay model, input current transducers are included. Depending of the HW, the following converter options can be selected: 0 to 5mA, -2.5 to +2.5 mA or 4 to 20 mA.

It is through the programmable logic that the converter can be allocated with a magnitude and a constant to represent the true reading (current, voltage, power,...) and the transformation ratio. The measured current in mA is turned into the actual measured magnitude and shown on the display (V, A, W,...).

Note: if range –2.5 to +2.5mA is selected, transducer measurement reaches +/-3mA. For a setting 0 to 5mA measurement reaches +5.587mA. For a setting 4 to 20mA measurement reaches up to 24mA.

3.22.5 Phase sequence

Power system's phase sequence (**ABC** or **ACB**) may be selected through **Phase Sequence** setting.

This setting tells the relay the actual system's phase sequence and, if the same analog current and voltage input connections for phases A, B and C are kept in the external connections diagram, all functions will work properly.

3.22.6 Line current. 6IRV-B Model

6IRV-B relays, designed for dual breaker bay protection (Breaker and a half or ring substations), incorporate a setting to allow defining line phase currents (IA, IB, IC) from phase currents measured by the relay (IA-1, IB-1, IC-1, IA-2, IB-2, IC-2). Possible setting values are: **I-1**, **I-2** and **I-1+I-2**. The first two values must be applied when the **6IRV-B** relay is installed in a single breaker bay, whereas the last value must be used when said relay is protecting a dual breaker bay.

It is worth highlighting that currents not considered by the **Line Current** setting will be cancelled by the relay. If the setting is for example **I-1**, the samples measured by current channels **I-2** will be 0, even if current is circulating through said channels.

3.22.7 General Settings

General Settings			
Setting	**Range**	**Step**	**By default**
Unit in service	YES / NO		YES
Phase CT Ratio	1 - 3000 1 - 10,000(*)	1	1
Ground CT Ratio (6IRV-A)	1 - 3000 1 - 10,000(*)	1	1
Polarizing CT Ratio	1 - 3000 1 - 10,000(*)	1	1
Phase VT Ratio	1 - 10,000 1 - 11,000(*)	1	1
Ground VT Ratio	1 - 10,000 1 - 11,000(*)	1	1
Synchronism 1 VT Ratio	1 - 10,000 1 - 11,000(*)	1	1
Synchronism 2 VT Ratio (6IRV-B)	1 - 10,000 1 - 11,000(*)	1	1
Synchronism 3 VT Ratio (6IRV-B)	1 - 10,000 1 - 11,000(*)	1	1
Neutral Voltage Origin	Transformer / Calculated		Transformer
Line current (6IRV-B)	I-1 / I-2 / I-1+I-2		I-1

(*) Models 6IRV-*-*****3* or higher.**

Transducers			
Setting	**Range**	**Step**	**By Default**
Transducer Type	0: 0 - 5 mA 1: -2.5¸ +2.5 mA		-2.5¸ +2.5 mA

Event Mask (only via communications)			
Event Mask	YES / NO		

- **General Settings: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - OPERATIONS	1 - PROTECTION	**1 - PHASE CT RATIO**
2 - CHANGE SETTINGS	...	**2 - GND CT RATIO**
3 - INFORMATION		**3 - POL. CT RATIO**
		4 - PHASE VT RATIO
		5 - BUSBAR VT RATIO
		6 - NEUTRAL VT RATIO
		7 - PHASE SEQUENCE
		8 - VN ORIGIN
		9 - TRANSDUCERS

6IRV-B MODELS

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - OPERATIONS	1 - PROTECTION	**1 - PHASE CT RATIO**
2 - CHANGE SETTINGS	...	**2 - POL. CT RATIO**
3 - INFORMATION		**3 - PHASE VT RATIO**
		4 - BUSBAR VT RATIO
		5 - BUSBAR 2 VT RATIO
		6 - BUSBAR 3 VT RATIO
		7 - NEUTRAL VT RATIO
		8 - PHASE SEQUENCE
		9 - LINE CURRENT
		10 - VN ORIGIN
		11 - TRANSDUCERS

3.23 Trip and Close Coil Circuit Supervision

3.23.1 Description

The Trip and Close Coil Circuit Supervision function permits an alarm when an anomalous situation occurs in the breaker's switching circuits: losses of the auxiliary switching power supply voltage or openings in the open and close circuits themselves. Up to three or six (depending on model) switching circuits can be monitored. Each of them can be set to both breaker positions (open and closed) or only to one of them.

The supervision function generates three (**6IRV-A**) or six (**6IRV-B**) outputs: **Circuit 1 Failure** (**FAIL_CIR1**), **Circuit 2 Failure** (**FAIL_CIR2**), **Circuit 3 Failure** (**FAIL_CIR3**), **Circuit 4 Failure** (**FAIL_CIR4**), **Circuit 5 Failure** (**FAIL_CIR5**) and **Circuit 6 Failure** (**FAIL_CIR6**), which the programmable logic can use to activate any of the IED's auxiliary contact outputs, also generating the corresponding events.

The six supervisions are treated separately as independent functions that can be independently set to enabled by means of a setting. Figure 3.23.1 is the block diagram showing the application in the situation of open breaker for two circuits with open and closed monitoring.

3.23.2 Operation Mode

There are settings for supervising the state of six coils: Trip Coil, Coil 2, Coil 3, Coil 4, Coil 5 and Coil 6. All of them may be trip or close. Hence their generic name. The activation of the **Trip/Close Circuit Failure** (**FAIL_CIRn**) of the coil or coils corresponding to the trip circuits may be used to, through the adequate programmable logic, impede the recloser from going on to initiate reclosing.

Each of the coils has an associated pair of configurable digital inputs for monitoring. They can be paired to **Monitor in 2 States**, which is explained next, or individually to **Monitor in 1 State**. In any case, both modes can be combined for different coils (for example, to monitor the trip coil in open and closed, and coil two only in open).

Table 3.23-1 identifies the status contact inputs that must be configured and used to monitor each of the circuits.

Table 3.23-1: Input Configuration for the Coil Circuit Supervision

Monitored Circuit	Supervision in 2 States	Supervision in 1 State
Coil 1	IN3	IN3
	IN4	-
Coil 2	IN6	IN6
	IN7	-
Coil 3	IN9	IN9
	IN10	-
Coil 4 (6IRV-B)	IN17	IN17
	IN18	-
Coil 5 (6IRV-B)	IN19	IN19
	IN20	-
Coil 6 (6IRV-B)	IN21	IN21
	IN22	-

Moreover, to monitor the **Coil 1**, a positive must be entered through terminal **IN2/CS1+**, to monitor the **Coil 2**, a positive must be entered through terminal **IN5/CS2+**, to monitor the **Coil 3**, a positive must be entered through terminal **IN8/CS3+**, and to monitor **Coils 4**, **5** and **6** a positive must be entered through terminal **IN6/CS4+**.

The IED needs no physical intervention to be able to assign status contact inputs for the monitor function; they simply need to be set for this purpose.

Each of the three or six coils can be configured as:

1. **No Supervision**. The supervision algorithm is not executed and the status contact inputs associated with the supervision of each of the coils are treated as standard status contact inputs.
2. **Supervision in 2 States**. The algorithm is the one indicated by way of example in figure 3.23.1 and explained in section 3.23.3. Basically, an XOR algorithm supervises the state of the switching circuit in open as well as in closed.
3. **Supervision in 1 State**. The algorithm only takes into account the supervision of the coil in the breaker's position configured in the input used for this purpose (IN3, IN7, IN9, IN17, IN19 or IN21). It does not monitor in the other position and therefore can never detect a fault in the coil.

For each of the monitored coils, it is possible to set a time after which, if there is discordance, the fault is activated.

Trip and close coil circuit monitoring is not sensitive to the impedance of the circuits seen from the relay. Its operating principle is based on an injection of current pulses that allows detecting continuity in those circuits. Every second a pulse of 100ms is sent, monitoring that the current circulates though the circuit. Current will not circulate if the auxiliary contact is open or the coil circuit is open.

3.23.3 Trip Coil Circuit

In the conditions of figure 3.23.1 (open breaker), current pulses are injected through inputs **IN3** and **IN4**. Because **IN3** is connected to contact **52/b**, which is closed, current flows through it and this is detected. No current flows through **IN4** and this fact is also detected. Given that the supervision has been programmed for **Supervision in 2 States**, the µController in charge of the management of this supervisory function will send a “0” logic to the main µProcessor and this will set the **FAIL_CIR1** (**Circuit Failure 1**) signal to “0” logic. In this situation it will be detected that the **IN3** digital input is activated and **IN4** is deactivated.

If the trip coil opens, the input that was activated, **IN3**, will deactivate and **IN4** will remain deactivated. After the configured **Trip Circuit Failure Reset Time**, the **Trip Circuit Failure 1** (**FAIL_CIR1**) signal will be given.

If a close or a reclosure occurs while the switching circuit is intact, once the command is executed, the state of the breaker and that of its **52/a** and **52/b** contacts changes. Consequently, the activation or deactivation of inputs **IN3** and **IN4** will invert and the **FAIL_CIR1** output will remain deactivated.

The purpose of the time delay is to compensate for the time gap between the closing of contact **52/a** and the opening of **52/b**. Generally, the **IN3** and **IN4** digital contacts do not change state simultaneously and, therefore, there will be a discordance between the two contacts. This will not modify the state of the **FAIL_CIR1** output as long as its duration is less than the set time.

If a trip occurs with the breaker closed and the breaker opens, inverting the state of contacts **52/a** and **52/b**, the **FAIL_CIR1** signal will not activate regardless of the duration of the trip command. If the breaker does not execute the command and the open command persists longer than the established reset time, the **FAIL_CIR1** signal will activate.

If the switching voltage disappears, the inputs that are energized will de-energize and this will activate both switching circuit failure outputs (**FAIL_CIR1** and **FAIL_CIR2**).

When the supervisory function of the trip coil detects the rupture of the circuit and, consequently, the impossibility of tripping, the sending of close commands to the breaker through the equipment should be impeded, manual as well as from the recloser, through the use of programmable logic from the equipment.

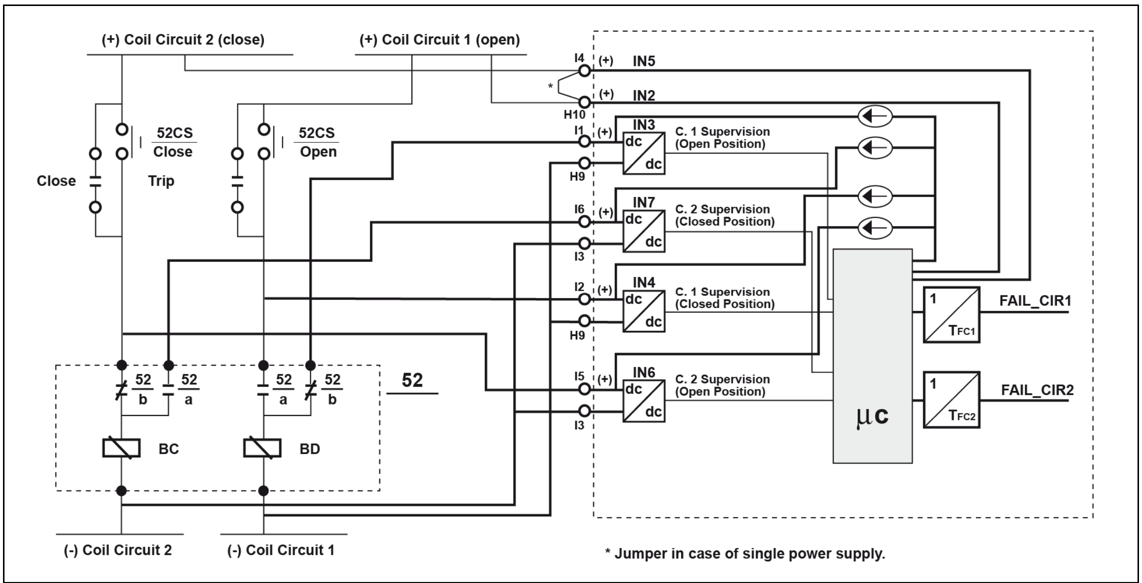


Figure 3.23.1: Trip/Close Coil Circuit Supervision Block Diagram.

3.23.4 Coil Circuits 2, 3, 4, 5 and 6

The explanation given for the open Circuit 1 is valid for the circuits of Coils 2, 3, 4, 5 and 6, referring to a possible close coil and to the corresponding operating circuit and changing the open commands for close commands, or to a second trip coil. Moreover, for coils 2, 3, 4, 5 and 6, the reset times for activating the failure output are independent of that indicated for the open circuit. The failure signal in the switching circuit is called **FAIL_CIR2**, **FAIL_CIR3**, **FAIL_CIR4**, **FAIL_CIR5** and **FAIL_CIR6**.

3.23.5 Trip and Close Coil Circuit Supervision Settings

Trip and Close Coil Circuit Supervision			
Setting	**Range**	**Step**	**By default**
Coil 1 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 1 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 2 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 2 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 3 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 3 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 4 Monitoring (6IRV-B)	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 4 failure time delay (6IRV-B)	1 - 50 s	0.01 s	0.2 s
Coil 5 Monitoring (6IRV-B)	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 5 failure time delay (6IRV-B)	1 - 50 s	0.01 s	0.2 s
Coil 6 Monitoring (6IRV-B)	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 6 failure time delay (6IRV-B)	1 - 50 s	0.01 s	0.2 s

- **Trip and Close Coil Circuit Supervision: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - CIRCUIT 1 COIL**
1 - OPERATIONS	...	**1 - CIR. 1 COIL FAIL.DLY**
2 - CHANGE SETTINGS	**5 - CIRCUIT COIL SUPERV**	**2 - CIRCUIT 2 COIL**
3 - INFORMATION	...	**3 - CIR. 2 COIL FAIL.DLY**
		4 - CIRCUIT 3 COIL
		5 - CIR. 3 COIL FAIL.DLY

6IRV-B MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - CIRCUIT 1 COIL**
1 - OPERATIONS	...	**1 - CIR. 1 COIL FAIL.DLY**
2 - CHANGE SETTINGS	**5 - CIRCUIT COIL SUPERV**	**2 - CIRCUIT 2 COIL**
3 - INFORMATION	...	**3 - CIR. 2 COIL FAIL.DLY**
		4 - CIRCUIT 3 COIL
		5 - CIR. 3 COIL FAIL.DLY
		6 - CIRCUIT 4 COIL
		7 - CIR. 4 COIL FAIL.DLY
		8 - CIRCUIT 5 COIL
		9 - CIR. 5 COIL FAIL.DLY
		10 - CIRCUIT 6 COIL
		11 - CIR. 6 COIL FAIL.DLY

3.23.6 Digital Outputs and Events of the Trip/Close Coil Circuit Supervision Module

Table 3.23-2: Digital Outputs and Events of the Trip/Close Coil Circuit Supervision Module

Name	Description	Function
FAIL_CIR1	Circuit #1 failure activated	They activate when an anomaly is detected in one or more of the switching circuits.
FAIL_CIR2	Circuit #2 failure activated	
FAIL_CIR3	Circuit #3 failure activated	
FAIL_CIR4	Circuit #4 failure activated (6IRV-B)	
FAIL_CIR5	Circuit #5 failure activated (6IRV-B)	
FAIL_CIR6	Circuit #6 failure activated (6IRV-B)	

3.24 Breaker Monitoring

3.24.1 Breaker Monitoring

To have suitable information for performing maintenance operations on the breaker, the **6IRV** IED records the interrupting current for each trip of the associated breaker and accumulates it as amperes squared. This number is proportional to the accumulated power actually interrupted by the breaker.

There is a magnitude called “interrupting current” that stores the value of the largest phase current measurement between a trip or manual open command and the opening of the breaker. The value of this magnitude updates whenever a trip or manual open command occurs. If there is an Open Command Failure, the value of the magnitude updates with the value 0.

When a trip is initiated, it accumulates the square of the largest phase current measured between the trip command and the opening of the breaker, multiplied by the transformation ratio. When it is a manual open, either through the IED itself or by external means, the element also saves the square of the largest phase current measured between the open command and the opening of the breaker, multiplied by the transformation ratio.

Once the value established for the alarm level is reached, the function activates an alarm signal that can be used by the programmable output function to activate an auxiliary contact output. When activated, the events recorder stores this output.

This function is controlled and consulted by means of two settings:

- Alarm Value of Cumulative Square Amps.
- Actual Value of Cumulative Square Amps.

This value is updated by protection whenever a trip or opening operation of the breaker is initiated, and can be modified manually. In the latter case, it represents the baseline value of accumulation to which successive interruption values are added. Manual modification allows setting an initial value corresponding to the breaker's interruption log upon installation of the IED and resetting it to zero after a maintenance operation.

The manual modification is not made by changing settings, since this value is not a proper setting; its modification requires a command through the programmable logic.

6IRV model makes a precise calculation of the arc energy dissipated by the breaker contacts. Said calculation is made for all breaker poles

The theoretical formula for the energy of the arc generated during the contact opening process will be: $E_{arc}=\int(I_{arc}*V_{arc})dt$, where I_{arc} and V_{arc} represent arc current and voltage. As $V_{arc}=I_{arc}*R_{arc}$, where R_{arc} is arc resistance, the above formula can be expressed as $E_{arc}=\int(I_{arc}^2*R_{arc})dt$. If a constant arc resistance is assumed, arc energy will be proportional to $I_{RMS}^2*T_{arc}$, where I_{RMS} is the calculated current RMS value during a time frame coinciding exactly with the arc duration and T_{arc} is the duration of the arc between the breaker contacts. **6IRV** relays calculate the above expression, with no need for using variable frames (T_{arc} varies from one opening to another), based on the following formula $I_{RMS}^2*T_{window}$, where T_{window}, representing the calculation time frame, is fixed and high enough to cover for arc duration. Based on typical arc durations included in Standard IEC T100a (from 4 to 25 ms), a calculation time frame of 2 cycles has been considered. Said time frame must start at the time when the arc is established between contacts, which can be determined in two ways:

- Taking into account the time when the corresponding breaker pole open signal (whether external or internal to the relay) activates, after adding said pole contact opening time (device operating time: breakers with 2, 3, 5 and 8 cycle operating time have typical contact opening times of 1.5, 2, 3 and 4 cycles).
- Taking into account breaker pole state contact (52b or 52a) operate time after subtracting said contact delay time with respect to the main contacts.

In order to select the most convenient way, based on breaker available information, the arc initiate signal (**breaker n** (n=1, 2 in **6IRV-B** relays) **pole X** (X=A, B, C) **Arc Initiate** input) can be configured through the programmable logic (opening signal or breaker state contacts). At the time of activation of said signal, a settable time (**Arc Initiate Delay**: from -1 to 50 cycles in ¼ cycle steps) is added or subtracted.

If neither the contact opening time nor the secondary contact (52b/52a) delay time with respect to the main contacts is known, neither the arc initiate time nor its duration can be calculated. In that case, the best choice is to consider an arc duration of 1 cycle letting the relay store the current RMS value with calculation time frames of equal duration (just setting **Calculation Time Frame** to 1 cycle), starting at the time of breaker pole open signal activation (set **Arc Initiate Delay** to 0 cycles).

6IRV relays generate the magnitude **Breaker n** (n=1, 2 in **6IRV-B** relays) **X Pole** (X=A, B, C) **Open Current**. Said magnitude equals the RMS value of the current circulating through breaker n X pole, calculated during the above defined frame. The value of this magnitude updates every time the **Breaker n X Pole Arc Initiate Input** activates, the calculation frame being completed and the **Breaker n X Pole Open Input** activated. The magnitude resets to 0 under various conditions:

- When, after completing the calculation frame, a **Breaker n X Pole Open Command Failure** occurs (in this case the **Breaker n X Pole Open Input** will not activate).
- When the **Calculation Frame Duration** setting sets to 0
- When the **Breaker n Current Buffer Block** input is activated**.** Said input prevents current buffers from increasing (see below) when relays are being checked with secondary injection equipment (during which the breaker current is zero).

Arc energy has been previously considered proportional to $I_{RMS}^2 * T_{arc}$, assuming constant arc resistance. Actually, arc resistance depends on the arc current value, thus arc energy will be proportional to $I_{RMS}^N * T_{arc}$, where N has a value between 1 and 2. The breaker manufacturer as a rule gives two figures of the number of operations at a given current: n1 operations at I1 kA and n2 operations at I2 kA. In order for the energy calculated for both current levels to be the same, an exponent N other than 2 must be used for the current: $n1*I1^N=n2*I2^N$. **6IRV** relays have the possibility to select the exponent N through a setting.

6IRV relays generate other magnitude, **Breaker n** (n=1, 2) **X** (X=A, B, C) **Pole Opened Current**, which stores the following value, every time the **Breaker n X Pole Open Current** updates:

$$\left(I_{RMS\_Xn} \times R_{TIABC}\right)^N \times T_{window}$$

where I_{RMS_Xn} represents the breaker n X pole opened current, R_{TIABC} represents the phase current transformation ratio, N represents the exponent selected and T_{window} represents the selected calculation time frame.

The total stored value is obtained as percentage of the **Stored Current Alarm** setting. When the **Breaker n X Pole Stored Current** magnitude reaches 100%, the function activates the **Breaker n X pole Stored Current** signal that can be used to activate one output through the programmable output function; also a write is added to the event recorder.

The stored current magnitude is updated every time the arc initiate input is activated, nevertheless said magnitude can be modified manually, via **Breaker n X Pole Stored Current Reset Command** input activation. In that case the latter magnitude will take the value of the **Breaker n X Pole Stored kA Reset Value** setting. Said setting represents the base stored value above which successive values corresponding to later openings will be added. Manual modification allows taking into account the breaker pole opening history when installing the relay and the updated value after a maintenance operation.

3.24.2 Excessive Number of Trips

The Excessive Number of Trips function is intended to interrupt an uncontrolled sequence of openings and closings that could damage the breaker. When a certain number of trips have occurred, adjustable between 1 and 40 in a definite time period (30 minutes), an output signal is generated and it can be connected to any of the IED's physical auxiliary contact outputs.

The activation of the **Excessive Number of Trips** output function disables any further reclose initiation by placing the recloser function (reclosers for the **6IRV-B** model) in the state of Recloser Lockout Due to Open Breaker status. This condition will reset only after a manual close command or a loss of auxiliary supply.

3.24.3 Breaker Operating Time (6IRV-B Model)

The models **6IRV-B** record the operating time of each breaker pole [magnitude **Pole X Fault Clearance Time** (X = A, B, C) **Breaker n** (n = 1, 2)] every time there is an open command. For this purpose the time is measured between the open command (signal **Pole X Breaker n Trip Command**) and the joint activation (**AND** operator) of the input **Pole X Breaker n Opened** and the pickup of the undercurrent unit, which operates with the current IX-n and takes as its pick up value the setting of **Phase X Opened Pole Current Level.** If a breaker pole open command has been issued, and an opening failure of this pole is detected, the clearance time of the fault will not be updated.

3.24.4 Breaker Monitoring Settings

Breaker Monitoring			
Setting	**Range**	**Step**	**By default**
Excessive number of trips	1 - 40	1	40
I2 sum alarm	0 - 99,999.99 kA^2	0.01	99,999.99
A pole cumulative preset value I2	0 - 99,999.99 kA^2	0.01	0 kA^2
B pole cumulative preset value I2	0 - 99,999.99 kA^2	0.01	0 kA^2
C pole cumulative preset value I2	0 - 99,999.99 kA^2	0.01	0 kA^2
kA index	1 - 2	0.1	2
Arc Initiate Delay	(-1) - 50 cycles	¼ cycle	0 cycles
Calculation frame duration	0 / 1 / 2 cycles	0.01	2 cycles

- **Breaker Monitoring: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - ENABLE EXCESS TRIP**
1 - OPERATIONS	...	**1 - EXCESSIVE TRIPS**
2 - CHANGE SETTINGS	**4 - BREAKER SUPERV.**	**2 - I^2 SUM ALARM**
3 - INFORMATION	...	**3 - I POLE A DROPOUT**
		4 - I POLE B DROPOUT
		5 - I POLE C DROPOUT
		6 - KA INDEX
		7 - ARC START DELAY
		8 - WINDOW LENGTH

6IRV-B MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - ENABLE EXCESS TRIP**
1 - OPERATIONS	…	**1 - EXCESSIVE TRIPS**
2 - CHANGE SETTINGS	**4 - BREAKER SUPERV.**	**2 - I1**
3 - INFORMATION	…	**3 - I1**

0 - GENERAL	0 - ENABLE EXCESS TRIP	**0 - I² SUM ALARM**
…	1 - EXCESSIVE TRIPS	**1 - I POLE A DROPOUT**
4 - BREAKER SUPERV.	**2 - I1**	**2 - I POLE B DROPOUT**
…	**3 - I1**	**3 - I POLE C DROPOUT**
		4 - KA INDEX
		5 - ARC START DELAY
		6 - WINDOW LENGTH

3.24.5 Digital Inputs and Events of the Breaker Monitoring Module

Table 3.24-1:Digital Inputs and Events of the Breaker Monitoring Module

Name	Description	Function
IN_BLK_KA	Current Store Block input (6IRV-A)	Activating this input blocks current store.
IN_BLK_KA1	Breaker 1 Current Store Block input (6IRV-B)	Activating this input blocks breaker 1 current store
IN_BLK_KA2	Breaker 2 Current Store Block input (6IRV-B)	Activating this input blocks breaker 2 current store.
RST_CUMIA	A Pole Stored Current Reset Command (6IRV-A)	Activating this input resets A Pole Stored Current magnitude to the "A Pole stored kA reset value" setting.
RST_CUMIB	B Pole Stored Current Reset Command (6IRV-A)	Activating this input resets B Pole Stored Current magnitude to the "B Pole stored kA reset value" setting.
RST_CUMIC	C Pole Stored Current Reset Command (6IRV-A)	Activating this input resets C Pole Stored Current magnitude to the "C Pole stored kA reset value" setting.

Table 3.24-1: Digital Inputs and Events of the Breaker Monitoring Module		
Name	**Description**	**Function**
RST_CUMIA1	Breaker 1 A Pole Stored Current Reset Command (6IRV-B)	Activating this input resets breaker 1 A Pole Stored Current magnitude to the "Breaker 1 A Pole stored kA reset value" setting.
RST_CUMIB1	Breaker 1 B Pole Stored Current Reset Command (6IRV-B)	Activating this input resets breaker 1 B Pole Stored Current magnitude to the "Breaker 1 B Pole stored kA reset value" setting.
RST_CUMIC1	Breaker 1 C Pole Stored Current Reset Command (6IRV-B)	Activating this input resets breaker 1 C Pole Stored Current magnitude to the "Breaker 1 C Pole stored kA reset value" setting.
RST_CUMIA2	Breaker 2 A Pole Stored Current Reset Command (6IRV-B)	Activating this input resets breaker 2 A Pole Stored Current magnitude to the "Breaker 2 A Pole stored kA reset value" setting.
RST_CUMIB2	Breaker 2 B Pole Stored Current Reset Command (6IRV-B)	Activating this input resets breaker 2 B Pole Stored Current magnitude to the "Breaker 2 B Pole stored kA reset value" setting.
RST_CUMIC2	Breaker 2 C Pole Stored Current Reset Command (6IRV-B)	Activating this input resets breaker 2 C Pole Stored Current magnitude to the "Breaker 2 C Pole stored kA reset value" setting.
IN_KA_STR_A	Arc pole A start input (6IRV-A)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker.
IN_KA_STR_B	Arc pole B start input (6IRV-A)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker.
IN_KA_STR_C	Arc pole C start input (6IRV-A)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker.

Table 3.24-1: Digital Inputs and Events of the Breaker Monitoring Module

Name	Description	Function
IN_KA_STR_A1	Breaker 1 Arc pole A start input (6IRV-B)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker 1.
IN_KA_STR_B1	Breaker 1 Arc pole B start input (6IRV-B)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 1.
IN_KA_STR_C1	Breaker 1 Arc pole C start input (6IRV-B)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 1.
IN_KA_STR_A2	Breaker 2 Arc pole A start input (6IRV-B)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker 2.
IN_KA_STR_B2	Breaker 2 Arc pole B start input (6IRV-B)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 2.
IN_KA_STR_C2	Breaker 2 Arc pole C start input (6IRV-B)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 2.

3.24.6 Digital Outputs and Events of the Breaker Monitoring Module

Table 3.24-2:Digital Outputs and Events of the Breaker Monitoring Module		
Name	**Description**	**Function**
EXC_NTRIP	Excessive number of trips	Indication that the maximum number of trips set has been reached.
AL_KA_A	Pole A accumulated Amps alarm (6IRV-A)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker have reached the alarm level.
AL_KA_B	Pole B accumulated Amps alarm (6IRV-A)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker have reached the alarm level.
AL_KA_C	Pole C accumulated Amps alarm (6IRV-A)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker have reached the alarm level.
AL_KA_A1	Breaker 1 Pole A accumulated Amps alarm (6IRV-B)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker 1 have reached the alarm level.
AL_KA_B1	Breaker 1 Pole B accumulated Amps alarm (6IRV-B)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 1 have reached the alarm level.
AL_KA_C1	Breaker 1 Pole C accumulated Amps alarm (6IRV-B)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 1 have reached the alarm level.
AL_KA_A2	Breaker 2 Pole A accumulated Amps alarm (6IRV-B)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker 2 have reached the alarm level.
AL_KA_B2	Breaker 2 Pole B accumulated Amps alarm (6IRV-B)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 2 have reached the alarm level.
AL_KA_C2	Breaker 2 Pole C accumulated Amps alarm (6IRV-B)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 2 have reached the alarm level.

3.24.7 Breaker Supervision Module Magnitudes

Table 3.24-3: Breaker Supervision Module Magnitudes

Name	Description	Function
IABI_A	Pole A Opened Current (6IRV-A)	
IABI_B	Pole B Opened Current (6IRV-A)	
IABI_C	Pole C Opened Current (6IRV-A)	
ACUMIAB_A	Pole A Stored Current (6IRV-A)	
ACUMIAB_B	Pole B Stored Current (6IRV-A)	
ACUMIAB_C	Pole C Stored Current (6IRV-A)	
IABI_A1	Breaker 1 Pole A Opened Current (6IRV-B)	A
IABI_B1	Breaker 1 Pole B Opened Current (6IRV-B)	A
IABI_C1	Breaker 1 Pole C Opened Current (6IRV-B)	A
IABI_A2	Breaker 2 Pole A Opened Current (6IRV-B)	A
IABI_B2	Breaker 2 Pole B Opened Current (6IRV-B)	A
IABI_C2	Breaker 2 Pole C Opened Current (6IRV-B)	A
ACUMIAB_A1	Breaker 1 Pole A Stored Current (6IRV-B)	% of breaker 1 stored kA Alarm Value
ACUMIAB_B1	Breaker 1 Pole B Stored Current (6IRV-B)	% of breaker 1 stored kA Alarm Value.
ACUMIAB_C1	Breaker 1 Pole C Stored Current (6IRV-B)	% of breaker 1 stored kA Alarm Value.
ACUMIAB_A2	Breaker 2 Pole A Stored Current (6IRV-B)	% of breaker 2 stored kA Alarm Value.
ACUMIAB_B2	Breaker 2 Pole B Stored Current (6IRV-B)	% of breaker 2 stored kA Alarm Value.
ACUMIAB_C2	Breaker 2 Pole C Stored Current (6IRV-B)	% of breaker 2 stored kA Alarm Value.
TFALTA_A1	Breaker 1 Pole A Operating Time (6IRV-B)	ms
TFALTA_B1	Breaker 1 Pole B Operating Time (6IRV-B)	ms
TFALTA_C1	Breaker 1 Pole C Operating Time (6IRV-B)	ms
TFALTA_A2	Breaker 2 Pole A Operating Time (6IRV-B)	ms
TFALTA_B2	Breaker 2 Pole B Operating Time (6IRV-B)	ms
TFALTA_C2	Breaker 2 Pole C Operating Time (6IRV-B)	ms

3.25 Change Settings Groups

3.25.1 Description

The **Protection**, **Logic** and **Recloser** settings include four alternative groups (GROUP 1, GROUP 2, GROUP 3 and GROUP 4), which can be activated or deactivated from the keypad, through the communication ports, by using external status contact inputs or with signals generated in the programmable logic.

This function permits modifying the active setting groups and, thereby, the response of the protection. This way, the behavior of the IED can adapt to changes in the external circumstances.

Two logic input signals can block changes in the active group from the HMI as well as via communications. When inputs **INH_CGRP_COM** and **INH_CGRP_HMI** are active, groups cannot be changed with commands via communications nor through the HMI.

If the status contact inputs are used to change groups, up to four status contact inputs may need to be configured through the programmable status contact inputs: **Command to Activate Settings Group 1 by Digital Input** (**CMD_GRP1_DI**), **Command to Activate Settings Group 2 by Digital Input** (**CMD_GRP2_DI**), **Command to Activate Settings Group 3 by Digital Input** (**CMD_GRP3_DI**) and **Command to Activate Settings Group 4 by Digital Input** (**T CMD_GRP4_DI**). There is another possible input whose function is to disallow group changes: **Inhibit Setting Group Control** (**INH_C_DE**).

Activating inputs **CMD_GRP1_DI**, **CMD_GRP2_DI**, **CMD_GRP3_DI** and **CMD_GRP4_DI** will activate GROUP 1, GROUP 2, GROUP 3 and GROUP 4 respectively.

If, while one of the inputs is active, either of the other three or several of them are activated, no group change will take place. The status contact settings group control logic will recognize a single input only. If all four inputs are deactivated, however, the IED will remain in the last active settings group.

Note: Groups can be changed by activating T1, T2 and T3 only if the display is in the default screen.

3.25.2 Digital Inputs and Events to Change Settings Groups

Table 3.25-1:Digital Inputs and Events to Change Settings Groups		
Name	**Description**	**Function**
INH_CGRP_COM	Inhibit group change via communications	It blocks any change of the active group by the PROCOME procedure.
INH_CGRP_HMI	Inhibit group change via HMI	It blocks any change of the active group through the HMI menu.
CMD_GRP1_COM	Command to activate settings group 1 via communications	Commands to change the active group.
CMD_GRP1_DI	Command to activate settings group 1 via DI	
CMD_GRP1_HMI	Command to activate settings group 1 via HMI	
CMD_GRP2_COM	Command to activate settings group 2 via communications	
CMD_GRP2_DI	Command to activate settings group 2 via DI	
CMD_GRP2_HMI	Command to activate settings group 2 via HMI	
CMD_GRP3_COM	Command to activate settings group 3 via communications	
CMD_GRP3_DI	Command to activate settings group 3 via DI	
CMD_GRP3_HMI	Command to activate settings group 3 via HMI	
CMD_GRP4_COM	Command to activate settings group 4 via communications	
CMD_GRP4_DI	Command to activate settings group 4 via DI	
CMD_GRP4_HMI	Command to activate settings group 4 via HMI	

3.25.3 Digital Outputs and Events to Change Settings Groups

Table 3.25-2: Digital Outputs and Events to Change Settings Groups

Name	Description	Function
T1_ACTIVATED	Settings group 1 activated	Indication of the active group.
T2_ACTIVATED	Settings group 2 activated	
T3_ACTIVATED	Settings group 3 activated	
T4_ACTIVATED	Settings group 4 activated	
INH_CGRP_COM	Inhibit group change via communications	The same as for the Digital Inputs.
INH_CGRP_HMI	Inhibit group change via HMI	
CMD_GRP1_COM	Command to activate settings group 1 via communications	The same as for the Digital Inputs.
CMD_GRP1_DI	Command to activate settings group 1 via DI	
CMD_GRP1_HMI	Command to activate settings group 1 via HMI	
CMD_GRP2_COM	Command to activate settings group 2 via communications	
CMD_GRP2_DI	Command to activate settings group 2 via DI	
CMD_GRP2_HMI	Command to activate settings group 2 via HMI	
CMD_GRP3_COM	Command to activate settings group 3 via communications	
CMD_GRP3_DI	Command to activate settings group 3 via DI	
CMD_GRP3_HMI	Command to activate settings group 3 via HMI	
CMD_GRP4_COM	Command to activate settings group 4 via communications	
CMD_GRP4_DI	Command to activate settings group 4 via DI	
CMD_GRP4_HMI	Command to activate settings group 4 via HMI	

3.26 Event Record

3.26.1 Description

The capacity of the recorder is 400 notations in non-volatile memory. The signals that generate the events are user-selectable and are recorded with a resolution of 1 ms together with a maximum of 12 values also selectable from all the available metering values measured or calculated by the IED (“user defined values”).

Each of the functions that the system uses records an event in the Event Record when any of the situations listed in the tables nested in the description of each function occur. Moreover, the events listed in Table 3.26-1 -the IED's general services- are also recorded. The tables mentioned above only list the events available with the default configuration. The list of signals can be expanded with those that the user configures in the programmable logic (any signal existing in the programmable logic can be configured to generate an event with the description that the user defines).

Table 3.26-1:Event Record

Name	Description
HMI access	See the description in Digital Outputs.
Clock synchronization	
IRIG-B active	
Oscilo arrancado	
Oscillography picked up	
Pole A open command (6IRV-A)	
Pole B open command (6IRV-A)	
Pole C open command (6IRV-A)	
Open command (6IRV-A)	
Open command pole A breaker 1 (6IRV-B)	
Open command pole B breaker 1 (6IRV-B)	
Open command pole C breaker 1 (6IRV-B)	
Open command pole A breaker 2 (6IRV-B)	
Open command pole B breaker 2 (6IRV-B)	
Open command pole C breaker 2 (6IRV-B)	
Open command breaker 1 (6IRV-B)	
Open command breaker 2 (6IRV-B)	
Open 52 button	
Open P1 button	
Open P2 button	
Open P3 button	
Open P4 button	
Open P5 button	
Open P6 button	
Close 52 button	
Close P1 button	
Close P2 button	
Close P3 button	
Close P4 button	
Close P5 button	
Close P6 button	

Table 3.26-1: Event Record	
Name	**Description**
Digital Input 1	See the description in Digital Outputs.
Digital Input 2	
Digital Input 3	
Digital Input 4	
Digital Input 5	
Digital Input 6	
Digital Input 7	
Digital Input 8	
Digital Input 9	
Digital Input 10	
Digital Input 11	
Digital Input 12	
Digital Input 13	
Digital Input 14	
Digital Input 15	
Digital Input 16	
Digital Input 17	
Digital Input 18	
Digital Input 19	
Digital Input 10	
Digital Input 21	
Digital Input 22	
Digital Input 23	
Digital Input 24	
Digital Input 25	
Digital Input 26	
Digital Input 27	
Digital Input 28	
Digital Input 29	
Digital Input 30	
Digital Input 31	
Digital Input 32	
Digital Input 33	
Digital Input 34	
Digital Input 35	
Digital Input 36	
Digital Input 37	
Validity of Digital Input 1	
Validity of Digital Input 2	
Validity of Digital Input 3	
Validity of Digital Input 4	
Validity of Digital Input 5	
Validity of Digital Input 6	
Validity of Digital Input 7	
Validity of Digital Input 8	
Validity of Digital Input 9	
Validity of Digital Input 10	

Table 3.26-1: Event Record	
Name	**Description**
Validity of Digital Input 11	See the description in Digital Outputs.
Validity of Digital Input 12	
Validity of Digital Input 13	
Validity of Digital Input 14	
Validity of Digital Input 15	
Validity of Digital Input 16	
Validity of Digital Input 17	
Validity of Digital Input 18	
Validity of Digital Input 19	
Validity of Digital Input 20	
Validity of Digital Input 21	
Validity of Digital Input 22	
Validity of Digital Input 23	
Validity of Digital Input 24	
Validity of Digital Input 25	
Validity of Digital Input 26	
Validity of Digital Input 27	
Validity of Digital Input 28	
Validity of Digital Input 29	
Validity of Digital Input 30	
Validity of Digital Input 31	
Validity of Digital Input 32	
Validity of Digital Input 33	
Validity of Digital Input 34	
Validity of Digital Input 35	
Validity of Digital Input 36	
Validity of Digital Input 37	
Auxiliary Output 1	
Auxiliary Output 2	
Auxiliary Output 3	
Auxiliary Output 4	
Auxiliary Output 5	
Auxiliary Output 6	
Auxiliary Output 7	
Auxiliary Output 8	
Auxiliary Output 9	
Auxiliary Output 10	
Auxiliary Output 11	
Auxiliary Output 12	
Auxiliary Output 13	
Auxiliary Output 14	
Auxiliary Output 15	
Auxiliary Output 16	
Auxiliary Output 17	
Auxiliary Output 18	
Auxiliary Output 19	
Auxiliary Output 20	

Table 3.26-1: Event Record	
Name	**Description**
Auxiliary Output 21	See the description in Digital Outputs.
Auxiliary Output 22	
Auxiliary Output 23	
Auxiliary Output 24	
Auxiliary Output 25	
Auxiliary Output 26	
Auxiliary Output 27	
Auxiliary Output 28	
Auxiliary Output 29	
Auxiliary Output 30	
Auxiliary Output 31	
Auxiliary Output 32	
Auxiliary Output 33	
Auxiliary Output 34	
Auxiliary Output 35	
Auxiliary Output 36	
Auxiliary Output 37	
Auxiliary Output 38	
Auxiliary Output 39	
Auxiliary Output 40	
Auxiliary Output 41	
Auxiliary Output 42	
Auxiliary Output 43	
Auxiliary Output 44	
LEDs reset input	
Power meters reset input	
Cold load pickup of IED	
Manual reinitialization of the IED	
Change of settings initialization	
Critical system error	
Non-critical system error	
System event	

The number of Digital Inputs and Auxiliary Outputs available will depend on each particular model.

All the configured events as well as the pre-existing ones in the default configuration can be masked.

The text indicated in the events tables is expanded with the message **Activation of...** when the event is generated by activation of any of the signals or **Deactivation of...** when the event is generated by deactivation of the signal.

3.26.2 Organization of the Event Record

The event record capacity is four hundred events. When the record is full, a new event displaces the oldest one. The following information is stored in each event register:

- Values of the 12 magnitudes selected at the time the event is generated.
- Event date and time.

Event recorder management is optimized so that simultaneous operations generated by the same event occupy a single position in the event memory. For example, the simultaneous occurrence of the phase A and neutral time overcurrent pickups are recorded in the same memory position. However, if the occurrences are not simultaneous, two separate events are generated. Simultaneous events are those operations occurring within a 1 ms interval, the resolution time of the recorder. Taking this feature into account, it could be said that the capacity of events is around one thousand events.

3.26.3 Event Mask

Use the general settings in communications to mask unneeded or unused events for system behavior analysis. Events are masked by communications within the General settings.

Important: Events that can be generated in excess should be masked since they could fill the memory (400 events) and erase more important previous events.

3.26.4 Consulting the Record

The communications and remote management program, ***ZIVercomPlus***®, has a completely decoded system for consulting the event record.

3.26.5 Event Record Settings (Via Communications)

Event Mask
Equipment events may be masked separately

Event Magnitudes (6IRV-A)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VG	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ SYNC	N.A.ENGY	M V1 06	M V2 06
IG	VCA	ROC FREQ	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	CUMIOPEN_A	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMIOPEN_B	C RECLO	M V1 09	M V2 09
PSC	PSV	CUMIOPEN_C	RECL MONO	M V1 10	MV2 10
NSC	NSV	OPENI_A	RECL TRIF	M V1 11	M V2 11
ZSC	ZSV	OPENI_B	N_OPENING_A	M V1 12	M V2 12
HARM2 IA	CMIN	OPENI_C	N_OPENING _B	M V1 13	M V2 13
HARM2 IB	CMAX	FAULTT	N_OPENING _C	M V1 14	M V2 14
HARM2 IC	VMIN	ACTGRP	N_CLOSING	M V1 15	M V2 15
	VMAX	THERMAL IMG		M V1 16	M V2 16
	PMIN	TRIPTYPE		N E AF 1	COLDSTARTS
	PMAX	TRANSDUCER		N E AF 2	WARMSTARTS
	QMIN			N E DF 1	NTRAPS
	QMAX			N E DF 2	FECHAULTDISP
	SMIN			N Er C 1	T_CORTOCIR
	SMAX			N Er C 2	

Event Magnitudes (6IRV-B)					
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:					
IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VG	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ S	N.A.ENGY	M V1 06	M V2 06
IG	VCA	FREQ S2	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	ROC FREQ	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMIOPEN_A1	REC1CYCLE	M V1 09	M V2 09
PSC	VSYNC2	CUMIOPEN_B1	REC2CYCLE	M V1 10	MV2 10
NSC	PSV	CUMIOPEN_C1	NSINGLEPHRECL1	M V1 11	M V2 11
ZSC	NSV	CUMIOPEN_A2	NSINGLEPHRECL2	M V1 12	M V2 12
IA1	ZSV	CUMIOPEN_B2	NTHREEPHRECL1	M V1 13	M V2 13
IB1	IMIN	CUMIOPEN_C2	NTHREEPHRECL2	M V1 14	M V2 14
IC1	IMAX	OPENI_A1	N_OPENING_A1	M V1 15	M V2 15
IA2	VMIN	OPENI _B1	N_OPENING_B1	M V1 16	M V2 16
IB2	VMAX	OPENI _C1	N_OPENING_C1	N E AF 1	COLDSTARTS
IC2	PMIN	OPENI _A2	N_OPENING_A2	N E AF 2	WARMSTARTS
IG1	PMAX	OPENI _B2	N_OPENING_B2	N E DF 1	NTRAPS
IG2	QMIN	OPENI _C2	N_OPENING_C2	N E DF 2	FECHAULTDISP
HARM2 IA	QMAX	FAULT	N_CLOSING_1	N Er C 1	T_CORTOCIR
HARM2 IB	SMIN	ACTGRP	N_CLOSING_2	N Er C 2	T_FLTCLEAR_A1
HARM2 IC	SMAX	THERMAL IMG			T_FLTCLEAR _B1
		FAULTIME			T_FLTCLEAR _C1
		TRANSDUCER			T_FLTCLEAR _A2
					T_FLTCLEAR _B2
					T_FLTCLEAR _C2

3.27 Fault Reports

3.27.1 Introduction

The terminal incorporates Fault Reports register, which stores the most relevant information about faults cleared by the IED. Access to this information is available through the communication ports. The information stored in each fault report is distributed in three tags: **Fault Initiation Time Tag**, **Open Command Time Tag** and **Fault End Time Tag**.

3.27.2 Fault Initiation Time Tag

Presents the date and time of the moment when the activation of the fault detector was produced or, if not activated, the start of the first element involved in the fault. Also included:

- **Pre-fault currents and voltages**. These are the values of the phase, ground, polarization and ground of the parallel line currents, and of the phase voltages (phase and line), ground and synchronism, two cycles prior to the commencement of the fault (activation of the fault detector or pick up of the first element involved in the fault). The values of the positive, negative and zero sequence currents and voltages are also noted. The currents as well as voltages (phase) are accompanied by their angles.
- **Elements picked up** for full fault duration.

3.27.3 Open Command Time Tag

It presents the date and time of the trip command and also displays:

- **Fault currents and voltages.** These are the values of the phase, ground and polarization, and of the phase voltages (phase and line), ground and synchronism, one and one-half cycles after the pick up of the first element involved in the fault. The values of the positive, negative and zero sequence currents and voltages are also noted. The currents as well as voltages (phase) are accompanied by their angles.
- **Trip generator units**, that is, those elements activated at the instant of the trip.
- **Fault Type**.
- **Trip Mode**. Indicates single-phase or three-phase trip.

3.27.4 Fault End Time Tag

It is the date and time of the reset of the last element involved in the fault.

Angle values included in the report use as reference the pre-fault phase A voltage. Each annotation of the fault report shows the following information at the time of the trip.

- Setting Group activated at time of trip.
- Reclose Sequence in which the equipment is found before the trip is produced.
- Frequency.
- Thermal State.

A magnitude, **Fault Duration** is generated from fault initiate and clearance labels, which is also included into the fault report.

Each record in the fault report includes the setting group active during the trip.

It should be pointed out that the indication of the type of fault will be UNKNOWN FAULT (DES) when all the elements and the trip are reset before the elapse of 1.5 cycles after the first pick up.

3.27.5 Fault Report on HMI

6IRV relays include the possibility to display fault reports on the HMI. To gain access to these records, enter the field **3- Information** → **7- Fault Reports**. Once the above field has been accessed, a list with the date and time of the last fault records will be displayed that will include the following information:

- Pick up and trip signals activated during the duration time of the fault: the short name of the signal will be used (refer to tables of digital outputs corresponding to each protection element). E.g. trip and pick up of the ground instantaneous overcurrent element 1 will be displayed as: **PU_IOC_N1** and **TRIP_IOC_N1**.
- Type of fault, type of trip, zone tripped, distance to fault, duration time of fault, active table, frequency, thermal state and reclose counter.
- Fault voltages and currents.

3.28 Metering Log

3.28.1 Operation

This function records the evolution of the values monitored at the point where the IED is installed. It samples each of the 12 values programmed for this purpose and calculates their average over the interval defined as **Averaging Calculation Time Interval**. This time interval is adjustable between 1 and 15 minutes. Each interval yields two values: the highest and the lowest of these magnitude averages.

The **Data Record Interval** is an adjustable period of time between 1 minute and 24 hours. The maximum and minimum averages recorded in the whole interval are recorded with their final time stamp. Figure 3.28.1 shows how the history record works.

- **AT** average calculation time interval; the figure shows an AT value of one minute.

- **RI**: data record interval; the figure shows a RI of 15 minutes.

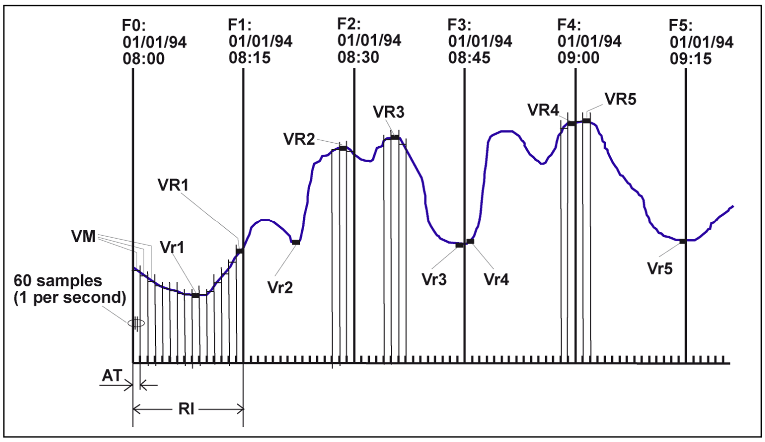


Figure 3.28.1: Explanatory Diagram of the Metering Log.

Each **AT** yields two **MV** values: the maximum and minimum averages. Each **RI** interval takes the maximum and minimum values of all the **MV**s computed. The profile of figure 3.28.1 yields the following values: VR1 - Vr1; VR2 - Vr2; VR3 - Vr3; VR4 - Vr4 and VR5 - Vr5.

Note: if phase or ground elements pick up during the average calculation time interval, the average of the measurements made while the elements were not picked up is recorded. Otherwise, if the elements remain picked up throughout the AT, the value recorded is: 0A / 0V.

As already indicated, twelve values can be configured among all the direct or calculated metering values ("user defined values") available in the IED (M_i). For each of the 12 values, up to four different metering values can be selected. For each of them, the greatest and the smallest of the three averages calculated along the **Averaging Calculation Time Interval** are found. See figure 3.28.2.

Thus, the greatest and the smallest value of all those calculated for each of the metering values that comprise each magnitude M_i are recorded.

The memory available for the metering log is RAM, large enough for 168 values. The memory can be customized by defining an **Hour Range** and **Day Calendar Mask** (the same hour range for all the days). No values outside the mask will be recorded.

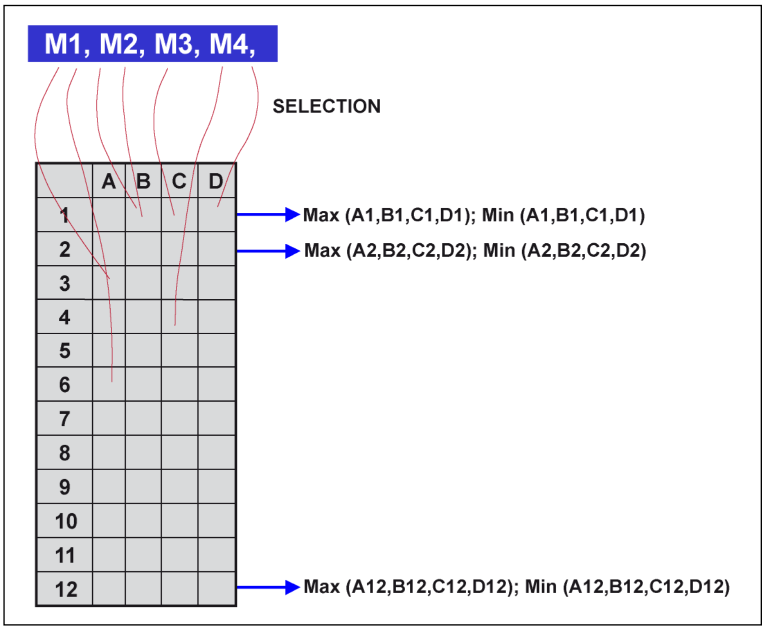


Figure 3.28.2: Metering Log Algorithm.

Likewise, the phase currents and voltages as well as the powers are constantly sampled. The sampled values are compared with those already stored. This keeps a maximum/minimum demand metering of the phase currents and voltages and of the active, reactive and apparent powers up to date.

These maximum and minimum values are stored in non-volatile memory, so they are reset by the logic input signal **Maximum Demand Element Reset**.

All this information is only available via communications through the communications and remote management program ***ZIVercomPlus***®.

3.28.2 Metering Log Settings

Metering Log			
Setting	**Range**	**Step**	**By default**
Sample interval	1 - 15 min		1 min
Historical data record interval	From 1 min to 24.00 h.		1 min
Day calendar mask	Monday to Sunday	YES / NO	YES
Calendar time mask	0 to 24.00 h		0 - 24 h

Log Groups (6IRV-A)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VG	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ SYNC	N.A.ENGY	M V1 06	M V2 06
IG	VCA	ROC FREQ	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	CUMIOPEN_A	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMIOPEN_B	C RECLO	M V1 09	M V2 09
PSC	PSV	CUMIOPEN_C	RECL MONO	M V1 10	M V2 10
NSC	NSV	OPENI_A	RECL TRIF	M V1 11	M V2 11
ZSC	ZSV	OPENI_B	N_OPENING_A	M V1 12	M V2 12
HARM2 IA	CMIN	OPENI_C	N_OPENING_B	M V1 13	M V2 13
HARM2 IB	CMAX	FAULTT	N_OPENING_C	M V1 14	M V2 14
HARM2 IC	VMIN	ACTGRP	N_CLOSING	M V1 15	M V2 15
	VMAX	THERMAL IMG		M V1 16	M V2 16
	PMIN	TRIPTYPE		N E AF 1	COLDSTARTS
	PMAX	TRANSDUCER		N E AF 2	WARMSTARTS
	QMIN			N E DF 1	NTRAPS
	QMAX			N E DF 2	FECHAULTDISP
	SMIN			N Er C 1	T_CORTOCIR
	SMAX			N Er C 2	

Log Groups (6IRV-B)					
There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:					
IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VG	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ S	N.A.ENGY	M V1 06	M V2 06
IG	VCA	FREQ S2	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	ROC FREQ	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMIOPEN_A1	REC1CYCLE	M V1 09	M V2 09
PSC	VSYNC2	CUMIOPEN_B1	REC2CYCLE	M V1 10	M V2 10
NSC	PSV	CUMIOPEN_C1	NSINGLEPHRECL1	M V1 11	M V2 11
ZSC	NSV	CUMIOPEN_A2	NSINGLEPHRECL2	M V1 12	M V2 12
IA1	ZSV	CUMIOPEN_B2	NTHREEPHRECL1	M V1 13	M V2 13
IB1	IMIN	CUMIOPEN_C2	NTHREEPHRECL2	M V1 14	M V2 14
IC1	IMAX	OPENI_A1	N_OPENING_A1	M V1 15	M V2 15
IA2	VMIN	OPENI_B1	N_OPENING_B1	M V1 16	M V2 16
IB2	VMAX	OPENI_C1	N_OPENING_C1	N E AF 1	COLDSTARTS
IC2	PMIN	OPENI_A2	N_OPENING_A2	N E AF 2	WARMSTARTS
IG1	PMAX	OPENI_B2	N_OPENING_B2	N E DF 1	NTRAPS
IG2	QMIN	OPENI_C2	N_OPENING_C2	N E DF 2	FECHAULTDISP
HARM2 IA	QMAX	FAULT	N_CLOSING_1	N Er C 1	T_CORTOCIR
HARM2 IB	SMIN	ACTGRP	N_CLOSING_2	N Er C 2	T_FLTCLEAR_A1
HARM2 IC	SMAX	THERMAL IMG			T_FLTCLEAR _B1
		FAULTIME			T_FLTCLEAR _C1
		TRANSDUCER			T_FLTCLEAR _A2
					T_FLTCLEAR _B2
					T_FLTCLEAR _C2

- **Metering Log: HMI Access**

0 - CONFIGURATION	0 - GENERAL	
1 - OPERATIONS	1 - PROTECTION	**0 - SAMPLE INTERVAL**
2 - CHANGE SETTINGS	...	**1 - LOG REC. INTERVAL**
3 - INFORMATION	**6 - HISTORY**	**2 - HIST. START TIME**
	...	**3 - HIST. END TIME**

3.29 Oscillographic Recording

3.29.1 Introduction

The oscillography function is composed of two different sub functions: **Capture** and **Display**. The first captures and stores protection data inside the IED and is part of the relay's software; the second retrieves and presents the stored data graphically with one or more programs running on a PC connected to the protection.

In **6IRV-A** relays, the sampling and storage frequency is fixed, 32 samples per cycle, and 15 seconds total storage. In **6IRV-B** relays, the storage frequency is selected through a setting (32 or 16 samples per cycle). If 16 samples per cycle is selected, total storage time is 30 seconds. Permanence of the information, with the IED disconnected from the power supply, is guaranteed for all relays during 28 days in 25º C.

The IEDs come with a display and analysis program, because the waveform records are in binary COMTRADE format according to IEEE standard C37.111-1999. The COMTRADE file generated considers the changes in frequency that can occur in the system, so that the analog magnitudes are stored with complete fidelity to how they have evolved on the system.

3.29.2 Capture Function

It is possible to record measured analog values, user defined values, digital inputs to the IED, internal logic signals generated by the protection and the programmable logic up to a total of 64 oscillographs in cyclical memory.

3.29.3 Stored Data

The following data are stored with a resolution time equal to the sampling rate:

- Value of the samples of the selected parameters (measured and user defined) and of the digital signals programmed for this purpose.
- Time stamp of the oscillography startup.

3.29.4 Number of Channels and Digital Signals

It is possible to record up to 15 analog values, depending in the model, enabling or disabling them via independent settings.

It is possible to include up to 5 user defined values. User defined values are every calculated value including those values calculated by the programmable logic via ***ZIVercomPlus***® software.

User defined values include any type of parameters. If sine waves are recorded the oscillography records the changes of the RMS value. Values are stored in the COMTRADE oscillography format with the label assigned in the programmable logic.

It is also possible to assign direct metering from the analog channels as an user defined value. Being waveforms the RMS value is stored. COMTRADE label is VALUE_u (ie. VA_u).

The maximum number of recorded digital signals is 80. Each user defined value configured in the oscillography counts as 16 digital signals.

3.29.5 Start Function

The Start Function is determined by a programmable mask applied to certain internal signals (element pickups, open command, etc.) and to an **External Pickup Signal** (which, if it is to be used, must be connected to any of the physical status contact inputs, to a programmable button of the HMI, to a command via communications or to a signal configured for this purpose in the programmable logic).

If the start function mask setting is **YES**, this signal activates the oscillography startup. This signal will not start the oscillography function if its mask setting is **NO**.

3.29.6 Oscillograph Deletion Function

Since the oscillograph records are stored in non-volatile memory, there is a mechanism that allows deleting all the content of this memory externally.

The oscillograph deletion function can operate by activating the **Deletion of Oscillographs** signal, which can be assigned by the programmable logic to any of the physical inputs, to a programmable button of the HMI, to a command via communications, etc.).

3.29.7 Trip Required

Data are stored only if a trip occurs within the time configured as oscillography record length.

3.29.8 Concatenation Stream Mode

The **YES** / **NO** setting allows extending the oscillography record length if new pickups of elements occur while one is being recorded. The recording system restarts the count of sequences to store if any other element picks up before the element generating the oscillography pickup resets.

It is possible for multiple triggers to occur during a fault. Sometimes these triggers are not simultaneous but they are staged in the early moments of a fault. The available memory to store oscillography is divided in zones, depending on the oscillography length setting. To optimize the memory management, for subsequent triggers (occurring after the first trigger), the length of the oscillograph will not be extended beyond the number of defined cycles by means of the **Interval between Triggers** setting.

3.29.9 Interval between Triggers

Interval between Triggers defines the minimum time required between different triggers, to extend the length of the oscillography record when the **Continuous Mode** setting is set to **YES**.

3.29.10 Pre-Fault Time

This is the length of pre-fault data that must be stored before the start function initiates a record. The setting range is from 0 to 25 pre-fault cycles.

3.29.11 Length of the Oscillograph

It is the fault record duration. The number of records stored in memory varies and depends on the number of channels recorded and the length of the fault records. Once the recording memory is full, the next event will overwrite the oldest one stored (FIFO memory).

The maximum number of waveform records is 64, and the maximum number of cycles that can be stored in memory is 725. Depending on the length selected, the maximum number varies

Set number of cycles	Maximum number of oscillographs
725	1
350	2
175	3
...	...
22	32
11	64

Note: when selecting the length of each oscillograph, it is important to take into account that if, for example, an oscillography record length greater than 350 cycles is selected, only one oscillograph can be stored.

3.29.12 Recording Frequency

6IRV-B relays incorporate a setting to select the sample storage frequency into the oscillograph. Two options of 32 and 16 samples per cycle are included, with total storage time of 15 and 30 seconds, respectively.

3.29.13 Oscillographic Recording Settings

Oscillographic Recording			
Setting	**Range**	**Step**	**By default**
Trip required	YES / NO		YES
Continuous mode	YES / NO		NO
Pretrigger length	0 - 25 cycles	1	5 cycles
Length (6IRV-A)	5 - 725 cycles	1	5 cycles
Length (6IRV-B)	5 - 1450 cycles	1	5 cycles
Interval between Triggers	1 - 725 cycles	1	4 cycles
Recording Frequency (6IRV-B)	32 m/c 16 m/c		32 m/c

Start Function		
Setting	**Step**	**By Default**
Thermal image unit	YES / NO	NO
Open phase unit	YES / NO	NO
Stub Bus Protection (6IRV-B)	YES / NO	NO
Pole discordance detector (6IRV-A)	YES / NO	NO
Pole discordance detector breaker 1 (6IRV-B)	YES / NO	NO
Pole discordance detector breaker 2 (6IRV-B)	YES / NO	NO
Phase time overcurrent (51-1)	YES / NO	NO
Phase time overcurrent (51-2)	YES / NO	NO
Phase time overcurrent (51-3)	YES / NO	NO
Phase instantaneous overcurrent (50-1)	YES / NO	NO
Phase instantaneous overcurrent (50-2)	YES / NO	NO
Phase instantaneous overcurrent (50-3)	YES / NO	NO

Start Function (Cont.)		
Setting	**Step**	**By Default**
Ground time overcurrent (51N-1)	YES / NO	NO
Ground time overcurrent (51N-2)	YES / NO	NO
Ground time overcurrent (51N-3)	YES / NO	NO
Ground instantaneous overcurrent (50N-1)	YES / NO	NO
Ground instantaneous overcurrent (50N-2)	YES / NO	NO
Ground instantaneous overcurrent (50N-3)	YES / NO	NO
Negative Sequence time overcurrent (51Q-1)	YES / NO	NO
Negative Sequence time overcurrent (51Q-2)	YES / NO	NO
Negative Sequence time overcurrent (51Q-3)	YES / NO	NO
Negative Sequence instantaneous overcurrent (50Q-1)	YES / NO	NO
Negative Sequence instantaneous overcurrent (50Q-2)	YES / NO	NO
Negative Sequence instantaneous overcurrent (50Q-3)	YES / NO	NO
Phase undervoltage (27-1)	YES / NO	NO
Phase undervoltage (27-2)	YES / NO	NO
Phase undervoltage (27-3)	YES / NO	NO
Phase overvoltage (59-1)	YES / NO	NO
Phase overvoltage (59-2)	YES / NO	NO
Phase overvoltage (59-3)	YES / NO	NO
Ground overvoltage (59N-1)	YES / NO	NO
Ground overvoltage (59N-2)	YES / NO	NO
Underfrequency (81m-1)	YES / NO	NO
Underfrequency (81m-2)	YES / NO	NO
Underfrequency (81m-3)	YES / NO	NO
Overfrequency (81M-1)	YES / NO	NO
Overfrequency (81M-2)	YES / NO	NO
Overfrequency (81M-3)	YES / NO	NO
Rate of Change (81D-1)	YES / NO	NO
Rate of Change (81D-2)	YES / NO	NO
Rate of Change (81D-3)	YES / NO	NO
Overexcitation (24) (6IRV-A)	YES / NO	NO
Overexcitation (24-1) (6IRV-B)	YES / NO	NO
Overexcitation (24-2) (6IRV-B)	YES / NO	NO
Overexcitation (24-3) (6IRV-B)	YES / NO	NO
Overexcitation (24-4) (6IRV-B)	YES / NO	NO
Breaker failure (configurable in the programmable logic)	YES / NO	NO
Retripping (A, B, C or 3Ph) (configurable in the programmable logic)	YES / NO	NO
External pickup	YES / NO	YES
Closing (manual or reclosing) (configurable in the programmable logic)	YES / NO	NO
Open command (configurable in the programmable logic)	YES / NO	NO
Programmable Trip	YES / NO	NO

Analog Channels (6IRV-A)	
1 - Phase A Voltage	5 - Phase A Current
2 - Phase B Voltage	6 - Phase B Current
3 - Phase C Voltage	7 - Phase C Current
4 - Ground Voltage	9 - Ground Current
5 - Synchronism Voltage	10 - Polarization Current

Analog Channels (6IRV-B)	
1 - Phase A Voltage	8 - Phase A Current 1
2 - Phase B Voltage	9 - Phase B Current 1
3 - Phase C Voltage	10 - Phase C Current 1
4 - Ground Voltage	11 - Phase A Current 2
5 - Synchronism 1 Voltage	12 - Phase B Current 2
6 - Synchronism 2 Voltage	13 - Phase C Current 2
7 - Synchronism 3 Voltage	14 - Polarization Current

Digital Channel Selection
Selectable from all configurable Digital Inputs and Digital Signals

- **Oscillographic Recording: HMI Access**

6IRV-A MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP REQUIRED**
1 - OPERATIONS	1 - PROTECTION	**1 - CONTINUOUS MODE**
2 - CHANGE SETTINGS	…..	**2 - PRETRIG. LENGTH**
3 - INFORMATION	**7 - OSCILLOGRAPHY**	**3 - LENGTH**
	…	**4 - TRIGGERS INTERVAL**
		5 - OSCILLO CHANN. MASK

6IRV-B MODELS

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP REQUIRED**
1 - OPERATIONS	1 - PROTECTION	**1 - CONTINUOUS MODE**
2 - CHANGE SETTINGS	…	**2 - PRETRIG. LENGTH**
3 - INFORMATION	**7 - OSCILLOGRAPHY**	**3 - LENGTH**
	…	**4 - TRIGGERS INTERVAL**
		5 - RECORDING FREQ
		6 - OSCILLO CHANN. MASK

3.29.14 Digital Inputs and Events of the Oscillographic Recording

Table 3.29-1: Digital Inputs and Events of the Oscillographic Recording		
Name	**Description**	**Function**
TRIG_EXT_OSC	External oscillography trigger	Input intended for external triggering.
DEL_OSC	Deletion of oscillographs command	The activation of this input deletes all the oscillographs stored.
ENBL_OSC	Oscillographic recording enable input	Activation of this input puts the element into service. The default value of this logic input signal is a "1."

3.29.15 Digital Outputs and Events of the Oscillographic Recording

Table 3.29-2: Digital Outputs and Events of the Oscillographic Recording		
Name	**Description**	**Function**
PU_OSC	Oscillography picked up	This output indicates that the oscillographic recording is on process.
OSC_ENBLD	Oscillographic recording enabled	Indication of enabled or disabled status of the element.
TRIG_EXT_OSC	External oscillography trigger	The same as for the Digital Input.
DEL_OSC	Deletion of oscillographs command	The same as for the Digital Input.
ENBL_OSC	Oscillographic recording enable input	The same as for the Digital Input.

3.30 Inputs, Outputs & LED Targets

3.30.1 Introduction

The **6IRV** has a flexible, user-definable structure of inputs / outputs and LEDs. It is described in the following sections. Factory programming included default values. Settings can be changed using the software package ***ZIVercomPlus***®.

3.30.2 Digital Inputs

The number of digital inputs available will depend on each particular model. All these inputs can be configured with any input signal to the pre-existing protection and control modules or defined by the user in the programmable logic.

The **Filtering** of the digital inputs can be configured with the following options:

- **Time between Samplings Filter 1** (**2-10 ms**): to establish the periodicity with which samples of the state of a digital input are taken.
- **Number of Samples with the same Value to Validate a Filter-1 Input** (**1-10**): the number of samples that must be detected consecutively to consider an input deactivated or activated can be set to logical "0" or "1" respectively.
- **Time between Samplings Filter 2** (**2-10 ms**): to establish the periodicity with which samples of the state of a digital input are taken.
- **Number of Samples with the same Value to Validate a Filter-2 Input** (**1-10**): The number of samples that must be detected consecutively to consider an input deactivated or activated can be set to logical "0" or "1" respectively.
- **Filter Assignation** (**Filter 1 / Filter 2**): Each configurable digital input can be assigned to "filter 1" or to "filter 2." The settings previously defined allow constructing filters 1 and 2 to create fast and slow detection inputs.
- **Number of Changes to Deactivate an Input and its Time Slot** (**2-60/1-30s**): an adjustable time slot is established to keep a digital input in which there is an external or internal malfunction to the relay from generating problems. This time slot monitors the number of times that this digital input changes condition. If this number of changes in state exceeds a set value, is disabled and the input keep on quite at its last status. Once an input is disabled, it will be enabled again when the enabling conditions are met or by an enabling command.
- **Number of Changes to Enable an Input and its Time Slot**: as for disabling, to enable an input again, there is also a time slot and a user-definable number of changes within that slot.

Some **6IRV** models have the following settings related to Digital Inputs:

- **DIs Supply Voltage Control** (YES / NO): Allows Digital Input validation control enable as a function of relay Supply voltage.
- **DIs Supply Voltage Level** (**24 / 48 / 125 / 125(>65%Vn) / 250 Vdc**): States relay rated supply voltage. When latter setting is set to **YES**, and relay supply voltage drops below DIs activation threshold, all validation signals are deactivated and the DIs disabled. Validation is reset when relay supply voltage exceeds DIs activation threshold. The supply voltage level is obtained through an input Vdc converter connected in parallel with the relay supply voltage. For DIs activation and deactivation thresholds as appropriate refer to Chapter 2.1
- **Automatic ED disable** (YES / NO): There is a separate setting for each Digital Input. If set to YES, allows for Automatic ED Disable on excessive number of changes (see in this same chapter the settings **Number of Changes for Disable** an input and **Time Window**).
- **Number of Digital Inputs for Supply Voltage supervision** (0 - 52) (*): Allows using a Digital Input as Supply Voltage reference. If the selected Digital Input is energized, Digital Inputs will remain active, otherwise, Digital Inputs will be deactivated and will reflect their last valid status. Selecting Digital Input 0, means this function is not used.
-

(*) The total number of Digital Inputs depends on model.

The IED's metering elements and logic functions use **Logic Input Signals** in their operation. They are enumerated in the tables nested in the description of each of them. Those corresponding to the IED's general services are listed in Table 3.30-1 and can be assigned to the **Physical Digital Inputs** or to logic output signals of opcodes configured in the programmable logic. More than one **Logic Input Signal** can be assigned to a **Single Status Contact Input**, but the same logic input signal cannot be assigned to more than one status contact input.

The tables mentioned above only list the inputs available with the default configuration. The list of inputs can be expanded with those that are configured in the programmable logic (any logic input signal created in the programmable logic can be used with the description that the user creates).

3.30.2.a Enable Input

Each protection element module of the relay has a special “logic input signal” to put it “In Service” or “Out of Service” from the HMI (buttons on the front), with a digital input by level and with the communications protocol configured in each port (control command).

This logic input signal is called **Enable Input…**. It combines with the **In Service** setting in this algorithm.

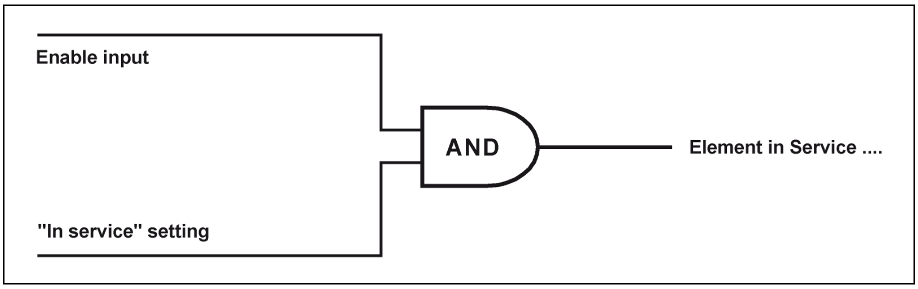


Figure 3.30.1: Element Enable Logic.

The default value of the logic input signal **Element Enable Input**... is a “1.” Therefore, when you do not configure the programmable logic at all, putting the protection elements into service depends only on the value of the **In Service** setting of each of them. The logic configuration to activate or switch off the enabling logic input signal will be as complicated or simple as you wish, from assigning it to a status contact input to building logical schemas with the various logic gates available (flip-flop’s, etc.).

Those protection functions that are put “out of service” by any of these methods will not generate or activate any of their associated logic signals, not even those that may be configured in the programmable logic and are directly related to these functions.

3.30.2.b Digital Inputs Settings

Digital Inputs			
Setting	**Range**	**Step**	**By Default**
Time Between Samples (Filter 1)	2 - 10 ms	2	6 ms
Time Between Samples (Filter 2)	2 - 10 ms	2	6 ms
Number of Samples to Validate Changes (Filter 1)	1 - 10 samples	1	2
Number of Samples to Validate Changes (Filter 2)	1 - 10 samples	1	2
Filter Assignation (independent setting for each DI)	0 = Filter 1 1 = Filter 2		Filter 1
Number of Changes to Disable	2 - 60 changes	1	5
Time to Disable	1 - 30 s	1	2 s
Number of Changes to Enable	2 - 60 changes	1	5
Time to Enable	1 - 30 s	1	2 s
Number of Digital Inputs for Supply Voltage Supervision	0 - 52 (*)	1	0
DIs Supply Voltage Control	0 = NO 1 = YES	1	0
DIs Supply Voltage Level	0 = 24 1= 48 2 = 125 3 = 125(>65%) 4 = 250	1	24
Automatic ED disable (independent for each IED digital input)	0 = NO 1 = YES	1	1

(*) The total number of Digital Inputs depends on model.

3.30.2.c Digital Inputs Table

Table 3.30-1:Digital Inputs		
Name	**Description**	**Function**
IN_RST_MAX	Maximeters reset	Its activation sets the content of the current, voltage and power demand elements to zero.
IN_PMTR_RST	Power meters reset	Its activation sets the content of the power meters to zero.
ENBL_PLL	Digital PLL input enable	Enables the operation of the automatic system to adapt to the frequency. By default, when not configured, it is a logic “1.”
LED_1	LED 1	They activate their corresponding LEDs.
LED_2	LED 2	
LED_3	LED 3	
LED_4	LED 4	
LED_5	LED 5	
LED_6	LED 6	
LED_7	LED 7	
LED_8	LED 8	
LED_9	LED 9	
LED_10	LED 10	
LED_11	LED 11	
LED_12	LED 12	
LED_13	LED 13	
LED_14	LED 14	
LED_15	LED 15	
LED_16	LED 16	
LED_52R	LED 52 Red	
LED_52G	LED 52 Green	
LED_P1R	LED P1 Red	
LED_P1G	LED P1 Green	
LED_P2R	LED P2 Red	
LED_P2G	LED P2 Green	
LED_P3R	LED P3 Red	
LED_P3G	LED P3 Green	
LED_P4R	LED P4 Red	
LED_P4G	LED P4 Green	
LED_P5R	LED P5 Red	
LED_P5G	LED P5 Green	
LED_P6R	LED P6 Red	
LED_P6G	LED P6 Green	

Table 3.30-1: Digital Inputs

Name	Description	Function
CMD_DIS_DI1	Command to disable digital input 1	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
CMD_DIS_DI2	Command to disable digital input 2	
CMD_DIS_DI3	Command to disable digital input 3	
CMD_DIS_DI4	Command to disable digital input 4	
CMD_DIS_DI5	Command to disable digital input 5	
CMD_DIS_DI6	Command to disable digital input 6	
CMD_DIS_DI7	Command to disable digital input 7	
CMD_DIS_DI8	Command to disable digital input 8	
CMD_DIS_DI9	Command to disable digital input 9	
CMD_DIS_DI10	Command to disable digital input 10	
CMD_DIS_DI11	Command to disable digital input 11	
CMD_DIS_DI12	Command to disable digital input 12	
CMD_DIS_DI13	Command to disable digital input 13	
CMD_DIS_DI14	Command to disable digital input 14	
CMD_DIS_DI15	Command to disable digital input 15	
CMD_DIS_DI16	Command to disable digital input 16	
CMD_DIS_DI17	Command to disable digital input 17	
CMD_DIS_DI18	Command to disable digital input 18	
CMD_DIS_DI19	Command to disable digital input 19	
CMD_DIS_DI20	Command to disable digital input 20	
CMD_DIS_DI21	Command to disable digital input 21	
CMD_DIS_DI22	Command to disable digital input 22	
CMD_DIS_DI23	Command to disable digital input 23	
CMD_DIS_DI24	Command to disable digital input 24	
CMD_DIS_DI25	Command to disable digital input 25	
CMD_DIS_DI26	Command to disable digital input 26	
CMD_DIS_DI27	Command to disable digital input 27	
CMD_DIS_DI28	Command to disable digital input 28	
CMD_DIS_DI29	Command to disable digital input 29	
CMD_DIS_DI30	Command to disable digital input 30	
CMD_DIS_DI31	Command to disable digital input 31	
CMD_DIS_DI32	Command to disable digital input 32	
CMD_DIS_DI33	Command to disable digital input 33	
CMD_DIS_DI34	Command to disable digital input 34	
CMD_DIS_DI35	Command to disable digital input 35	
CMD_DIS_DI36	Command to disable digital input 36	
CMD_DIS_DI37	Command to disable digital input 37	
CMD_DIS_DI38	Command to disable digital input 38	
CMD_DIS_DI39	Command to disable digital input 39	
CMD_DIS_DI40	Command to disable digital input 40	
CMD_DIS_DI41	Command to disable digital input 41	
CMD_DIS_DI42	Command to disable digital input 42	
CMD_DIS_DI43	Command to disable digital input 43	
CMD_DIS_DI44	Command to disable digital input 44	
CMD_DIS_DI45	Command to disable digital input 45	
CMD_DIS_DI46	Command to disable digital input 46	
CMD_DIS_DI47	Command to disable digital input 47	
CMD_DIS_DI48	Command to disable digital input 48	

Table 3.30-1: Digital Inputs		
Name	**Description**	**Function**
CMD_DIS_DI49	Command to disable digital input 49	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
CMD_DIS_DI50	Command to disable digital input 50	
CMD_DIS_DI51	Command to disable digital input 51	
CMD_DIS_DI52	Command to disable digital input 52 (*)	
REMOTE	Remote	Sets the relay in remote mode. Must be activated to enable DNP 3.0 commands.
LOCAL	Local Control	Means 'Local Commands' enabled, whose performance is defined in user's logic module.
CONTROL_PANEL	Operation Desk control	Means 'Operation Desk Commands' enabled, whose performance is defined in user's logic module.
CMD_ENBL_DI1	Command to enable digital input 1	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
CMD_ENBL_DI2	Command to enable digital input 2	
CMD_ENBL_DI3	Command to enable digital input 3	
CMD_ENBL_DI4	Command to enable digital input 4	
CMD_ENBL_DI5	Command to enable digital input 5	
CMD_ENBL_DI6	Command to enable digital input 6	
CMD_ENBL_DI7	Command to enable digital input 7	
CMD_ENBL_DI8	Command to enable digital input 8	
CMD_ENBL_DI9	Command to enable digital input 9	
CMD_ENBL_DI10	Command to enable digital input 10	
CMD_ENBL_DI11	Command to enable digital input 11	
CMD_ENBL_DI12	Command to enable digital input 12	
CMD_ENBL_DI13	Command to enable digital input 13	
CMD_ENBL_DI14	Command to enable digital input 14	
CMD_ENBL_DI15	Command to enable digital input 15	
CMD_ENBL_DI16	Command to enable digital input 16	
CMD_ENBL_DI17	Command to enable digital input 17	
CMD_ENBL_DI18	Command to enable digital input 18	
CMD_ENBL_DI19	Command to enable digital input 19	
CMD_ENBL_DI20	Command to enable digital input 20	
CMD_ENBL_DI21	Command to enable digital input 21	
CMD_ENBL_DI22	Command to enable digital input 22	
CMD_ENBL_DI23	Command to enable digital input 23	
CMD_ENBL_DI24	Command to enable digital input 24	
CMD_ENBL_DI25	Command to enable digital input 25 (*)	

Table 3.30-1: Digital Inputs		
Name	**Description**	**Function**
DO_1	Digital output 1	They activate their corresponding outputs.
DO_2	Digital output 2	
DO_3	Digital output 3	
DO_4	Digital output 4	
DO_5	Digital output 5	
DO_6	Digital output 6	
DO_7	Digital output 7	
DO_8	Digital output 8	
DO_9	Digital output 9	
DO_10	Digital output 10	
DO_11	Digital output 11	
DO_12	Digital output 12 (*)	

(*) The total number of Digital Inputs / Outputs depends on model.

3.30.3 Auxiliary Outputs

The number of digital outputs available will depend on each particular model. They can all be configured with any input or output signal of the pre-existing protection and control modules or defined by the user in the programmable logic. Auxiliary outputs use NO contacts.

The IED's metering elements and logic functions generate a series of logic output signals. Each of these signals has either a “true” or “false” value and this status can be used as an input to either of the combinational logic gates shown in figure 3.30.2. The use of the combinational logic gates described in figure is optional. Its purpose is to facilitate the simplest configurations. To develop more complex algorithms and be able to assign the resulting outputs to auxiliary contact outputs, the necessary opcodes must be programmed in the programmable logic.

The outputs from the blocks described in figure 3.30.2 can be connected to one of the programmable auxiliary contact outputs in the IED. There is an additional, non-programmable auxiliary output contact corresponding to relay **In Service**.

Two blocks of eight inputs are available. One of the blocks performs an **OR** operation with the selected signals (any signal activates the logic gate output). The other block performs an **AND** operation with the selected signals (all signals need to be active to activate the logic gate output). The result of these two blocks is then operated through either an **AND** or an **OR** gate. The pulse option can be added to the result of this operation. It works as follows:

- **Without Pulses**: by adjusting the pulse timer to 0, the output signal remains active as long as the signal that activated it lasts.
- **With Pulses**: once the output signal is activated, it remains the set time whether or not the signal that generated it is deactivated before or remains active.

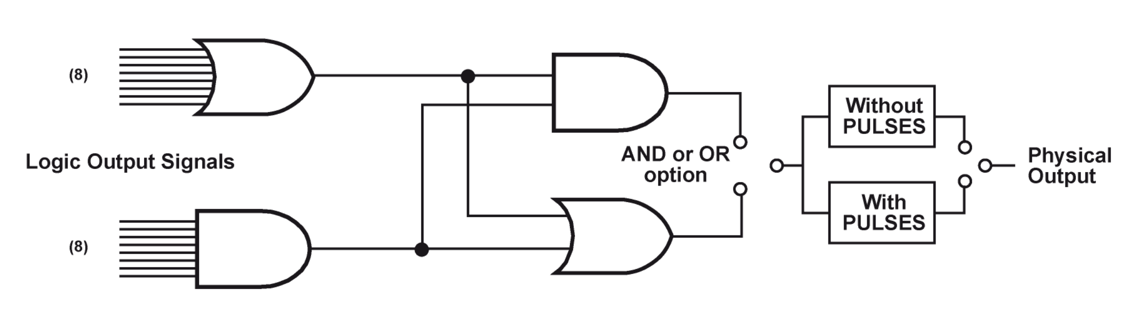


Figure 3.30.2: Auxiliary Contact Output Logic Cell Block Diagram.

All the logic output signals listed in the tables nested in the description of each of the elements are user-definable. Moreover, the signals indicated in Table 3.30-2, all corresponding to the IED's general services, can also be assigned.

The tables mentioned only list the logical outputs available with the default configuration. The list of signals can be expanded with those configured in the programmable logic (any logic signal created in the programmable logic can be used with the description that the user creates).

3.30.3.a Auxiliary Outputs Table

Table 3.30-2: Auxiliary Outputs

Name	Description	Function
ACCESS_HMI	HMI access	Indication that the HMI has been accessed.
SYNC_CLK	Clock synchronization	Indication of having received a date / time change.
UN_ACT	Any element activated	They indicate that any protection element is picked up.
UN_PU	Any element picked up	
OPEN_CMD	Open command	Commands that go to the relay's trip and close contacts.
CLOSE	Close command	
RST_IND_TRIP	Reset command of trip indication	Indicates a trip reset from HMI
B_OPEN_52	Open button 52	They indicate that the corresponding button has been pressed.
B_OPEN _P1	Open button P1	
B_OPEN_P2	Open button P2	
B_OPEN_P3	Open button P3	
B_OPEN_P4	Open button P4	
B_OPEN_P5	Open button P5	
B_OPEN_P6	Open button P6	
B_CLS_52	Close button 52	
B_CLS_P1	Close button P1	
B_CLS_P2	Close button P2	
B_CLS_P3	Close button P3	
B_CLS_P4	Close button P4	
B_CLS_P5	Close button P5	
B_CLS_P6	Close button P6	

Table 3.30-2: Auxiliary Outputs		
Name	**Description**	**Function**
IN_1	Digital input 1	They indicate that the corresponding input has been activated.
IN_2	Digital input 2	
IN_3	Digital input 3	
IN_4	Digital input 4	
IN_5	Digital input 5	
IN_6	Digital input 6	
IN_7	Digital input 7	
IN_8	Digital input 8	
IN_9	Digital input 9	
IN_10	Digital input 10	
IN_11	Digital input 11	
IN_12	Digital input 12	
IN_13	Digital input 13	
IN_14	Digital input 14	
IN_15	Digital input 15	
IN_16	Digital input 16	
IN_17	Digital input 17	
IN_18	Digital input 18	
IN_19	Digital input 19	
IN_20	Digital input 20	
IN_21	Digital input 21	
IN_22	Digital input 22	
IN_23	Digital input 23	
IN_24	Digital input 24	
IN_25	Digital input 25	
IN_26	Digital input 26	
IN_27	Digital input 27	
IN_28	Digital input 28	
IN_29	Digital input 29	
IN_30	Digital input 30	
IN_31	Digital input 31	
IN_32	Digital input 32	
IN_33	Digital input 33	
IN_34	Digital input 34	
IN_35	Digital input 35	
IN_36	Digital input 36	
IN_37	Digital input 37	
IN_38	Digital input 38	
IN_39	Digital input 39	
IN_40	Digital input 40	
IN_41	Digital input 41	
IN_42	Digital input 42	
IN_43	Digital input 43	
IN_44	Digital input 44	
IN_45	Digital input 45	
IN_46	Digital input 46	
IN_47	Digital input 47	

Table 3.30-2: Auxiliary Outputs

Name	Description	Function
IN_48	Digital input 48	They indicate that the corresponding input has been activated.
IN_49	Digital input 49	
IN_50	Digital input 50	
IN_51	Digital input 51	
IN_52	Digital input 52 (*)	
VAL_DI_1	Validity of digital input 1	They indicate whether the input has been enabled or disabled.
VAL_DI_2	Validity of digital input 2	
VAL_DI_3	Validity of digital input 3	
VAL_DI_4	Validity of digital input 4	
VAL_DI_5	Validity of digital input 5	
VAL_DI_6	Validity of digital input 6	
VAL_DI_7	Validity of digital input 7	
VAL_DI_8	Validity of digital input 8	
VAL_DI_9	Validity of digital input 9	
VAL_DI_10	Validity of digital input 10	
VAL_DI_11	Validity of digital input 11	
VAL_DI_12	Validity of digital input 12	
VAL_DI_13	Validity of digital input 13	
VAL_DI_14	Validity of digital input 14	
VAL_DI_15	Validity of digital input 15	
VAL_DI_16	Validity of digital input 16	
VAL_DI_17	Validity of digital input 17	
VAL_DI_18	Validity of digital input 18	
VAL_DI_19	Validity of digital input 19	
VAL_DI_20	Validity of digital input 20	
VAL_DI_21	Validity of digital input 21	
VAL_DI_22	Validity of digital input 22	
VAL_DI_23	Validity of digital input 23	
VAL_DI_24	Validity of digital input 24	
VAL_DI_25	Validity of digital input 25	
VAL_DI_26	Validity of digital input 26	
VAL_DI_27	Validity of digital input 27	
VAL_DI_28	Validity of digital input 28	
VAL_DI_29	Validity of digital input 29	
VAL_DI_30	Validity of digital input 30	
VAL_DI_31	Validity of digital input 31	
VAL_DI_32	Validity of digital input 32	
VAL_DI_33	Validity of digital input 33	
VAL_DI_34	Validity of digital input 34	
VAL_DI_35	Validity of digital input 35	
VAL_DI_36	Validity of digital input 36	
VAL_DI_37	Validity of digital input 37	
VAL_DI_38	Validity of digital input 38	
VAL_DI_39	Validity of digital input 39	
VAL_DI_40	Validity of digital input 40	
VAL_DI_41	Validity of digital input 41	
VAL_DI_42	Validity of digital input 42	

Table 3.30-2: Auxiliary Outputs		
Name	**Description**	**Function**
VAL_DI_43	Validity of digital input 43	They indicate whether the input has been enabled or disabled.
VAL_DI_44	Validity of digital input 44	
VAL_DI_45	Validity of digital input 45	
VAL_DI_46	Validity of digital input 46	
VAL_DI_47	Validity of digital input 47	
VAL_DI_48	Validity of digital input 48	
VAL_DI_49	Validity of digital input 49	
VAL_DI_50	Validity of digital input 50	
VAL_DI_51	Validity of digital input 51	
VAL_DI_52	Validity of digital input 52 (*)	
CMD_DIS_DI1	Command to disable digital input 1	The same as for the digital inputs.
CMD_DIS_DI2	Command to disable digital input 2	
CMD_DIS_DI3	Command to disable digital input 3	
CMD_DIS_DI4	Command to disable digital input 4	
CMD_DIS_DI5	Command to disable digital input 5	
CMD_DIS_DI6	Command to disable digital input 6	
CMD_DIS_DI7	Command to disable digital input 7	
CMD_DIS_DI8	Command to disable digital input 8	
CMD_DIS_DI9	Command to disable digital input 9	
CMD_DIS_DI10	Command to disable digital input 10	
CMD_DIS_DI11	Command to disable digital input 11	
CMD_DIS_DI12	Command to disable digital input 12	
CMD_DIS_DI13	Command to disable digital input 13	
CMD_DIS_DI14	Command to disable digital input 14	
CMD_DIS_DI15	Command to disable digital input 15	
CMD_DIS_DI16	Command to disable digital input 16	
CMD_DIS_DI17	Command to disable digital input 17	
CMD_DIS_DI18	Command to disable digital input 18	
CMD_DIS_DI19	Command to disable digital input 19	
CMD_DIS_DI20	Command to disable digital input 20	
CMD_DIS_DI21	Command to disable digital input 21	
CMD_DIS_DI22	Command to disable digital input 22	
CMD_DIS_DI23	Command to disable digital input 23	
CMD_DIS_DI24	Command to disable digital input 24	
CMD_DIS_DI25	Command to disable digital input 25	
CMD_DIS_DI26	Command to disable digital input 26	
CMD_DIS_DI27	Command to disable digital input 27	
CMD_DIS_DI28	Command to disable digital input 28	
CMD_DIS_DI29	Command to disable digital input 29	
CMD_DIS_DI30	Command to disable digital input 30	
CMD_DIS_DI31	Command to disable digital input 31	
CMD_DIS_DI32	Command to disable digital input 32	
CMD_DIS_DI33	Command to disable digital input 33	
CMD_DIS_DI34	Command to disable digital input 34	
CMD_DIS_DI35	Command to disable digital input 35	
CMD_DIS_DI36	Command to disable digital input 36	
CMD_DIS_DI37	Command to disable digital input 37	

Table 3.30-2: Auxiliary Outputs		
Name	Description	Function
CMD_DIS_DI38	Command to disable digital input 38	The same as for the digital inputs.
CMD_DIS_DI39	Command to disable digital input 39	
CMD_DIS_DI40	Command to disable digital input 40	
CMD_DIS_DI41	Command to disable digital input 41	
CMD_DIS_DI42	Command to disable digital input 42	
CMD_DIS_DI43	Command to disable digital input 43	
CMD_DIS_DI44	Command to disable digital input 44	
CMD_DIS_DI45	Command to disable digital input 45	
CMD_DIS_DI46	Command to disable digital input 46	
CMD_DIS_DI47	Command to disable digital input 47	
CMD_DIS_DI48	Command to disable digital input 48	
CMD_DIS_DI49	Command to disable digital input 49	
CMD_DIS_DI50	Command to disable digital input 50	
CMD_DIS_DI51	Command to disable digital input 51	
CMD_DIS_DI52	Command to disable digital input 52 (*)	
CMD_ENBL_DI1	Command to enable digital input 1	The same as for the digital inputs.
CMD_ENBL_DI2	Command to enable digital input 2	
CMD_ENBL_DI3	Command to enable digital input 3	
CMD_ENBL_DI4	Command to enable digital input 4	
CMD_ENBL_DI5	Command to enable digital input 5	
CMD_ENBL_DI6	Command to enable digital input 6	
CMD_ENBL_DI7	Command to enable digital input 7	
CMD_ENBL_DI8	Command to enable digital input 8	
CMD_ENBL_DI9	Command to enable digital input 9	
CMD_ENBL_DI10	Command to enable digital input 10	
CMD_ENBL_DI11	Command to enable digital input 11	
CMD_ENBL_DI12	Command to enable digital input 12	
CMD_ENBL_DI13	Command to enable digital input 13	
CMD_ENBL_DI14	Command to enable digital input 14	
CMD_ENBL_DI15	Command to enable digital input 15	
CMD_ENBL_DI16	Command to enable digital input 16	
CMD_ENBL_DI17	Command to enable digital input 17	
CMD_ENBL_DI18	Command to enable digital input 18	
CMD_ENBL_DI19	Command to enable digital input 19	
CMD_ENBL_DI20	Command to enable digital input 20	
CMD_ENBL_DI21	Command to enable digital input 21	
CMD_ENBL_DI22	Command to enable digital input 22	
CMD_ENBL_DI23	Command to enable digital input 23	
CMD_ENBL_DI24	Command to enable digital input 24	
CMD_ENBL_DI25	Command to enable digital input 25	
CMD_ENBL_DI26	Command to enable digital input 26	
CMD_ENBL_DI27	Command to enable digital input 27	
CMD_ENBL_DI28	Command to enable digital input 28	
CMD_ENBL_DI29	Command to enable digital input 29	
CMD_ENBL_DI30	Command to enable digital input 30	
CMD_ENBL_DI31	Command to enable digital input 31	
CMD_ENBL_DI32	Command to enable digital input 32	
CMD_ENBL_DI33	Command to enable digital input 33	

Table 3.30-2: Auxiliary Outputs		
Name	**Description**	**Function**
CMD_ENBL_DI34	Command to enable digital input 34	The same as for the digital inputs.
CMD_ENBL_DI35	Command to enable digital input 35	
CMD_ENBL_DI36	Command to enable digital input 36	
CMD_ENBL_DI37	Command to enable digital input 37	
CMD_ENBL_DI38	Command to enable digital input 38	
CMD_ENBL_DI39	Command to enable digital input 39	
CMD_ENBL_DI40	Command to enable digital input 40	
CMD_ENBL_DI41	Command to enable digital input 41	
CMD_ENBL_DI42	Command to enable digital input 42	
CMD_ENBL_DI43	Command to enable digital input 43	
CMD_ENBL_DI44	Command to enable digital input 44	
CMD_ENBL_DI45	Command to enable digital input 45	
CMD_ENBL_DI46	Command to enable digital input 46	
CMD_ENBL_DI47	Command to enable digital input 47	
CMD_ENBL_DI48	Command to enable digital input 48	
CMD_ENBL_DI49	Command to enable digital input 49	
CMD_ENBL_DI50	Command to enable digital input 50	
CMD_ENBL_DI51	Command to enable digital input 51	
CMD_ENBL_DI52	Command to enable digital input 52 (*)	
DO_1	Digital output 1	The same as for the digital inputs.
DO_2	Digital output 2	
DO_3	Digital output 3	
DO_4	Digital output 4	
DO_5	Digital output 5	
DO_6	Digital output 6	
DO_7	Digital output 7	
DO_8	Digital output 8	
DO_9	Digital output 9	
DO_10	Digital output 10	
DO_11	Digital output 11	
DO_12	Digital output 12	
DO_13	Digital output 13	
DO_14	Digital output 14	
DO_15	Digital output 15	
DO_16	Digital output 16	
DO_17	Digital output 17	
DO_18	Digital output 18	
DO_19	Digital output 19	
DO_20	Digital output 20	
DO_21	Digital output 21	
DO_22	Digital output 22	
DO_23	Digital output 23	
DO_24	Digital output 24	
DO_25	Digital output 25	
DO_26	Digital output 26	
DO_27	Digital output 27	
DO_28	Digital output 28	

Table 3.30-2: Auxiliary Outputs

Name	Description	Function
DO_29	Digital output 29	The same as for the digital inputs.
DO_30	Digital output 30	
DO_31	Digital output 31	
DO_32	Digital output 32	
DO_33	Digital output 33	
DO_34	Digital output 34	
DO_35	Digital output 35	
DO_36	Digital output 36	
DO_37	Digital output 37	
DO_38	Digital output 38	
DO_39	Digital output 39	
DO_40	Digital output 40	
DO_41	Digital output 41	
DO_42	Digital output 42	
DO_43	Digital output 43	
DO_44	Digital output 44	
DO_45	Digital output 45	
DO_46	Digital output 46 (*)	
LED_1	LED 1	The same as for the digital inputs.
LED_2	LED 2	
LED_3	LED 3	
LED_4	LED 4	
LED_5	LED 5	
LED_6	LED 6	
LED_7	LED 7	
LED_8	LED 8	
LED_9	LED 9	
LED_10	LED 10	
LED_11	LED 11	
LED_12	LED 12	
LED_13	LED 13	
LED_14	LED 14	
LED_15	LED 15	
LED_16	LED 16	
LED_52R	LED 52 Red	
LED_52G	LED 52 Green	
LED_P1R	LED P1 Red	
LED_P1G	LED P1 Green	
LED_P2R	LED P2 Red	
LED_P2G	LED P2 Green	
LED_P3R	LED P3 Red	
LED_P3G	LED P3 Green	
LED_P4R	LED P4 Red	
LED_P4G	LED P4 Green	
LED_P5R	LED P5 Red	
LED_P5G	LED P5 Green	
LED_P6R	LED P6 Red	
LED_P6G	LED P6 Green	

Table 3.30-2: Auxiliary Outputs		
Name	**Description**	**Function**
IN_RST_LED	LEDs reset input	Resets the LEDs that are active because they are memorized.
IN_PMTR_RST	Power meters reset input	The same as for the digital input.
IN_RST_MAX	Maximeters reset	Its activation sets the content of the current, voltage and power demand elements to zero.
ENBL_PLL	Digital PLL input enable	The same as for the digital input.
CUR_LINE	Indicator of current in the line	It is activated when some of the phase currents are higher than 0.1 A.
RST_MAN	Manual reinitialization of the relay	It is marked whenever the IED is reset manually.
PU_CLPU	Cold load pickup of relay	It is marked whenever the IED is energized.
PU_WLPU	Warm pickup of relay	It is activated after any reset (configuration loading, manual reset,…), while remaining de device powered-up.
EDIG_VF	Digital Input Supply Voltage Failure	They activate on lack of voltage at the digital input selected for Digital Input supervision.
INIT_CH_SET	Change of settings initialization	It is indicated when some setting is modified.
FAIL_COM_L	Port 0 communication failure	They activate when no communication port activity is detected during the set time.
FAIL_COM_R1	Port 1 communication failure	
FAIL_COM_R2	Port 2 communication failure	
FAIL_COM_R3	Port 3 communication failure	
FAIL_COM_CAN	Port CAN communication failure	
REMOTE	Remote	Sets the relay in remote mode. Must be activated to enable DNP 3.0 commands.
LOCAL	Local Control	Means 'Local Commands' enabled, whose performance is defined in user's logic module.
CONTROL_PANEL	Operation Desk control	Means 'Operation Desk Commands' enabled, whose performance is defined in user's logic module.
ERR_CRIT	Critical system error	They note that some technical problem has cropped up in the IED.
ERR_NONCRIT	Non-critical system error	
EVENT_SYS	System event	Indicates the reset of SW in the IED.

(*) The total number of Digital Inputs / Outputs depends on model.

Configuration for outputs can be loaded at the factory. Users can easily program different output configurations using the ***ZivercomPlus***® software via the local communication ports that have the PROCOME protocol configured (the local port is always assigned this protocol).

3.30.3.b Trip and Close Outputs

The **6IRV** IED has four switching output signals, two of them normally open (N/O) and the other two definable by jumper as N/O or N/C. Two of these switching outputs are assigned to the logic output called open. These outputs are activated both when the relay generates a trip and when the breaker is opened manually. In all cases, they remain active for at least 100 ms.

The activation of the logical input **Trip External Control** will block all the open commands to the CB. If activated before the unit pick-up, both internal signals **Trip** and **Masked Trip** would be activated but without causing the trip of the Circuit Breaker. However, if activated after the tripping of the Circuit Breaker then it resets all protection units and tripping commands.

The other pair of switching output signals are assigned to the **Close** logic output. These outputs are activated both when the recloser function generates a reclose command and when the breaker is closed manually.

Breaker trip and close operations can be made using the same trip and reclosure contacts. The operating mode, through the button frame on the front of the IED, is designed to always request confirmation of manoeuvres before executing them.

Both for manual and protection element-generated or reclose-generated operations, if a breaker state change signal is not received, after an operate command is sent, within the operate failure time (settable separately for open and close operations), **Open Command Failure** or **Close Command Failure** signals are activated.

3.30.4 LED Targets

The **6IRV** IED has optical indicators (LEDs) on the front panel. One of them indicates whether the IED is **Ready**.

Each of the user-definable optical indicators is associated to a combinatorial function. These are diagrammed in figure 3.30.3. They way they function and are configured is similar to the auxiliary contact outputs. One of the two blocks has eight inputs that perform an OR operation (any signal activates the output). The other block has one input. The two blocks together can perform an OR or an AND operation without the subsequent possibility of using pulses.

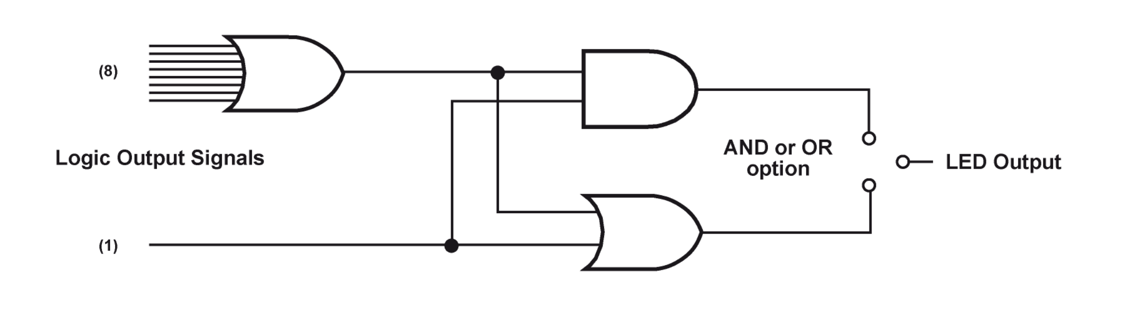


Figure 3.30.3: Target Output Logic Cell Block Diagram.

Each LED can be latched or unlatched. If an LED is latched, it will remain illuminated until reset. It is possible to program one of the programmable buttons, communications command, or digital input with the **Reset LEDs** digital input. Since it is defined as a command it will be available in the operations display menu. The latching function resides in the volatile memory section of the microprocessor. A power supply loss will cause any latched LED to reset.

The LEDs can be associated to any of the available logic output signals indicated in table 3.30-2. Logic equations can be created and modified with the ***ZivercomPlus***® program via the local communication ports that have the PROCOME protocol configured (the local port is always assigned this protocol).

To develop more complex algorithms and be able to assign the resulting outputs to the LEDs, the necessary opcodes must be programmed in the programmable logic. This, for example, allows configuring latched LEDs that do not lose memory after an auxiliary power supply voltage failure. This requires the use of latched bistable circuits.

Additionally, the **6IRV** IED has another 7 LEDs associated with each of the operating buttons available on the front of the IED. These indicators show the current state of the element governed by each button by its color (user-configurable). In the process of selecting an element and confirming / executing a command, the associated LED blinks. These LEDs must be configured through the programmable logic.

3.30.5 Digital Inputs, Auxiliary Outputs and LEDs Test

Apply rated voltage, appropriate for the model. At this time, the **In Service** LED should be lit.

- **Digital Inputs**

For the inputs test, the rated voltage is applied between the terminals corresponding to the inputs (marked in the external connections diagram), always taking the polarity of the contacts into account.

From the inputs screen of the **Information** menu, it is verified that the inputs are activated (“1”). The voltage is removed and the contact inputs must reset (“0”).

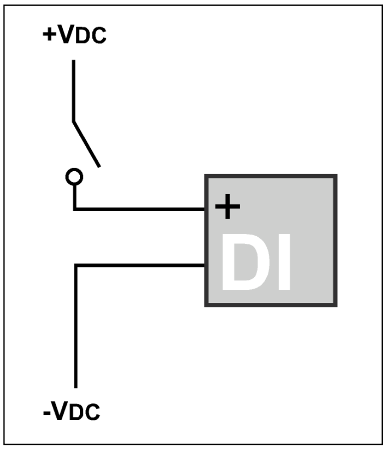


Figure 3.30.4: Digital Inputs Test.

- **Auxiliary Outputs**

To test the auxiliary contact outputs, their operation is provoked according to how they are configured. If they are not configured, they can be configured as activation of the status contact inputs. Part of the inputs test consists in verifying the operation of auxiliary output contacts OUT1 to OUT6.

- **Selection and Command Buttons and Associated LEDs**

To test the definable selection and command buttons on the front of the IED, they are assigned a configuration such that, once they have been selected and the command given, the corresponding auxiliary contact outputs (indicated in the external connections scheme) are activated and deactivated.

Pressing the **52** key causes the associated LED to blink; then pressing the **I** or **O** key enables the **Close** (**TRIP 1**) or **Trip** (**CLOSE1**) contacts as long as the breaker element is in the position contrary to the selected one.

Pressing the **P1** to **P6** keys after the configuration indicated above has been made, causes the LEDs corresponding to each of them to blink. Then, pressing the **I** or **O** key enables the contacts corresponding to the auxiliary contact outputs OUT1 to OUT6.

- **LED Targets**

To check the LED targets, the **F2** key must be pressed from the stand-by screen until the Resetting LEDs screen appears. It is held down until all the LEDs light up. When the push-button is released, they must all go off.

3.31 Programmable Logic

3.31.1 Description

One of the functions of **6IRV** models is a fully configurable one called Programmable Logic. The user can freely interconnect this logic digitally and analogically by using the ***ZIVercomPlus***® program.

All the signals generated by the equipment will be available to the events, fault reports, oscillograph records, digital inputs and outputs, HMI and communications according to how their programmable logic has been configured.

The inputs to the logic functions can be any of the signals or readings generated by the following functions:

- Protection units.
- Digital inputs.
- Communications.
- Command functions.
- Analog inputs.

The user can define a logical operation using primitive logic functions (AND, OR, XOR, NOT, etc.), bistable circuits (latched or not), timers, comparators, constants, values, etc.

The programming function allows definition of the trip logic, control logic, interlocks, functional modules, local and remote states and control hierarchy required for complete protection and operation of a bay.

Priorities may also be selected in the programmable logic. There are three run cycles, of 2, 10 and 20 milliseconds, and priorities may be allocated placing the logics in either cycle. In this way, control logic can be carried out and use them as protection functions as they can be run with a priority similar to the functions implemented into the equipment firmware itself. For more information, please refer to the ***ZivercomPlus***® manual.

The processing of the input signals produces logical outputs that can be assigned to existing connections between the **6IRV** and the exterior: auxiliary output contacts, display, LEDs, communications, HMI, etc.

3.31.2 Functional Characteristics

The IEDs can execute local programmable control functions associated with the bay as well as the logic associated with internal and external interlockings, treatment and generation of alarms and processing of signals. They are all programmable.

The execution of interlockings towards the external circuits implies being able to execute continuously active outputs depending on the combination of the state of various input signals through logic gates. These interlocking outputs are used for interrupting / continuing an exterior command circuit. These interlockings are the consequence of the logic capacity pointed out in the following sections.

The execution of internal interlockings implies being able to obtain logic outputs of permission / blocking of commands towards the external circuits according to the combination of the state of various input signals through logic gates. These processed logic signals affect the permissions / lockouts of commands generated both from the unit's local control module and from the Central Unit originating in the control display, central programmable control functions and/or remote control.

Logical alarms can be generated with data from the combination of the state of various input signals through logic gates as well as from "timers" of presence / absence of a given signal, either physical or logic.

The processing of analog signals offers the possibility of comparing analog inputs with set points and of generating digital ON/OFF signals as a result of this comparison as well as the possibility of adding and multiplying analog signals. Analog values can be used in primary or secondary values.

Logic configurations can also generate user defined values such as counters. This values are the result of the user defined logic algorithms. User defined values can be displayed on the HMI, sent via communications and retrieved using ***ZIVercomPlus***®.

Likewise, it is also possible to define new user settings in the IED associated with the algorithm. These settings can be consulted afterwards from the HMI or communications.

In addition, the algorithms can disable protection elements of the IED. The disabling of an element allows it to be replaced by another that operates under user-defined algorithms.

Basically, the system takes input signals from various sources, both external to the IED (communications or HMI) and internal; processes these signals according to the configuration that has been loaded and the pre-established settings and activates certain output signals that will be used for sending information messages or measurements to the central unit as well as commands to relays, LEDs and protection.

The **Programmable Logic** and its **Configuration** comprise the engine of this whole system. The logic has a set of *blocks* that encompass a series of logic operations. Each of these blocks determines an *outcome* (state of one or more signals) depending on the state of the inputs of that *block*. The **Configuration** determines the use of one or another block.

The operation chosen to obtain a given output determines the input signals to the *blocks*. The **Input Connection** process is the software process that connects the inputs of the *blocks* with the appropriate inputs to the control subsystem according to the **Configuration**.

Likewise, the output signals from the *blocks* are associated with the appropriate outputs. This is done in the **Output Connecting** process according to the **Configuration**.

If the required input signals are signals that arrive through communications, they arrive encoded according to the PROCOME, MODBUS or DNP 3.0 communications protocol, which forces associating each necessary signal with its corresponding protocol. This process is performed in **Input Tagging** and the associations are made in one form or another according to the configuration. The same happens with the signals sent through communications; the software process is carried out in **Output Tagging** and is also determined by the **Configuration**.

New logic-generated values can be redirected to the IED's different communication protocols as well as to the HMI.

The **Programmable Logic** can be used to generate events with any available digital signal that the IED can capture with the PROCOME communications protocol and the program. It doesn't matter if this signal is a digital input or a signal received via communications from the central unit or, on the contrary, is the outcome of internal operations included in the programmed algorithm itself. Moreover, there is the option of recording the event by the rising edge of the chosen signal, by the falling edge or by both.

Once the event is generated, it can be captured the same as the rest of the events generated by the IED (as, for example, trip events) with the ***ZIVercomPlus***® communications program.

There is an exclusive option to simplify the task of configuring the Digital Inputs, Digital Outputs and LEDs. This voids the need to work with complex algorithms that would make the task unnecessarily difficult.

3.31.3 Primitive Functions (Opcodes)

The following logic operations can be used in the algorithm.

AND	Pulse	Adder	Digital/Analog Converter
OR	Timer A	Subtracter	BCD/Analog Converter
XOR	Timer B	Multiplier	Binary/Analog Converter
NOT	DFF	Divisor	Analog/BCD Converter
Cable	RSFF	Comparator	Analog/Binary Converter
Multifiber Cable	Analog Cable	Level Comparator	Pulse train
Multiplexer	Counter		Rising edge

- **AND**

Performs an AND operation between digital signals.

Operands:

From 2 to 16 digital input signals

Results:

Digital output signal, the outcome of the operation

- **OR**

Performs an OR operation between digital signals.

Operands:

From 2 to 16 digital input signals

Results:

Digital output signal, the outcome of the operation

- **XOR**

Performs an XOR operation between two digital signals.

Operands:

Two digital input signals.

Results:

Digital output signal, the outcome of the operation.

- **NOT**

Moves to a digital signal the outcome of negating another.

Operands:

Digital input signal.

Results:

Digital input signal.

- **Cable**

Moves to a digital signal the value of another.

Operands:

Digital input signal.

Results:

Digital input signal.

- **Multifiber Cable**

Moves to a digital signal the value of another.

Operands:

Digital input signal.

Results:

From 1 to 16 digital output signals.

- **Multiplexer**

Based on a selector, it establishes the value of an output signal with the value of one of the two inputs.

Operands:

Digital input selector signal.
2 digital input signals.

Results:

Digital output signal.

- **Analog Selector**

Based on a selector, it establishes the value of an analog output magnitude with the value of one of the two analog input magnitudes.

Operands:

Digital input selector signal.
2 analog input magnitudes.

Results:

Analog output magnitude.

- **Pulse**

When the input signal goes from 0 to 1, the output signal is activated during the time specified as parameter.

Operands:

Digital input signal.
Setting or pulse time constant in seconds.

Results:

Digital output signal.

Limits:

The maximum time must be set between 0.0 and 2147483.648 seconds (24 days).

- **Timer A**

When the time set since the input signal went from 0 to 1 is up, the output goes to one until the input resets.

Operands:

Digital input signal.
Setting or delay time constant in seconds.

Results:

Digital output signal.

Limits:

The maximum time must be set between 0.0 and 2147483.648 seconds (24 days).

- **Timer B**

The output is activated as long as the input is active or has been deactivated after a time no greater than the time set.

Operands:

Digital input signal.
Setting or delay time constant in seconds.

Results:

Digital output signal.

Limits:

The maximum time must be set between 0.0 and 2147483.648 seconds (24 days).

- **DFF**

Type D bistable. Whenever a rising edge occurs in the clock signal, the bistable takes the value of the input.

Operands:

Digital clock signal.
Digital input signal.

Results:

Digital output signal

- **RSFF**

Type RS bistable. As long as the S signal is active, the bistable takes the value of the input. When the R input is activated, the bistable takes value 0.

Operands:

Digital signal R.
Digital signal S.

Results:

Digital output signal.

- **Analog Cable**

Moves to an analog magnitude the value of another.

Operands:

Input magnitude.

Results:

Output magnitude.

- **Counter**

It manages a counter that increases with each rising edge of the clock signal. When the reset input is activated, the counter resets to 0.

Operands:

Digital reset signal.
Digital clock signal.

Results:

Magnitude of counter value.

Limits:

The counter has a saturation value of 65535. Subsequent increments do not modify the output value of the counter.

- **Adder**

It establishes the value of the output magnitude with the result of the sum of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Subtracter**

It establishes the value of the output magnitude with the result of the subtraction of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Multiplier**

It establishes the value of the output magnitude with the result of the product of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Divisor**

It establishes the value of the output magnitude with the result of the division of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Comparator**

Compares two input values and establishes the value of the digital output signal according to the outcome of the comparison.

Operands:

2 input values, settings or constants.
Type of comparison as a constant value inserted in the opcode:
Greater than.
Less than.
Equal to.
Not equal to.
Greater than or equal to.
Less than or equal to.

Results:

Digital output signal.

- **Level Comparator**

It compares the input magnitude with respect to a minimum and maximum reference value and establishes the output according to it. Thus:
The output is 1 if the input is greater than the maximum reference value.
The output is 0 if the input is less than the minimum reference value.
Otherwise, the output keeps the same value.

Operands:

Input magnitude (magnitude, setting or constant).
Minimum reference value (magnitude, setting or constant).
Maximum reference value (magnitude, setting or constant).

Results:

Digital output signal.

- **Digital / Analog Converter**

It converts a digital signal to an analog magnitude with value 0 or 1.

Operands:

Digital input signal.

Results:

Analog output magnitude.

- **BCD / Analog Converter**

With 16 digital inputs, it generates an analog magnitude using BCD code.

Operands:

16 digital input signals.

Results:

Analog output magnitude.

- **Binary / Analog Converter**

With 16 digital inputs, it generates an analog magnitude using binary code.

Operands:

16 digital input signals.

Results:

Analog output magnitude.

- **Analog / BCD Converter**

It converts an analog magnitude into 16 digital signals by converting to BCD code.

Operands:

Analog input magnitude.

Results:

16 digital output signals.

- **Analog / Binary Converter**

It converts an analog magnitude into 16 digital signals by converting to binary code.

Operands:

Analog input magnitude.

Results:

16 digital output signals.

- **Pulse Train**

Logic block produced by a pulse train while the digital input signal is active.

Operands:

Digital signal enabling pulse train.
Magnitude, setting or time constant of active pulse in seconds.
Magnitude, setting or time constant of inactive pulse in seconds.

Results:

Digital output signal.

- **Rising Edge**

The output is activated when a change from 0 to 1 is detected in the input.

Operands:

Digital input signal.

Results:

Digital output signal.

3.31.3.a Logic Operations with Memory

Certain logical functions can be configured to preserve the internal state of the function after a shut down. Not all the logical functions have internal states that require this treatment:

Table 3.31-1: Logic Operations with Memory

Logical function	Can be memorized
AND	-
OR	-
XOR	-
NOT	-
Cable	-
Multifiber cable	-
Pulse	Y
Timer A	Y
Timer B	Y
DFF	Y
RSFF	Y
Analog cable	-
Counter	Y
Adder	-
Subtracter	-
Multiplier	-
Divisor	-
Comparator	-
Level comparator	Y
Digital to analog	-
RSFF with timed reset	Y
Pulse train	Y

Memorization mode is selected by means of a memory field inserted in the opcode when configuring with the ***ZIVercomPlus***® program.

Chapter 3. Functions and Description of Operation

3.32 Communications

3.32.1 Communications Types

6IRV relays are provided with different types of communications ports as a function of the selected model:

- **1** front **Local Port** type RS232C and USB.
- Up to **3 Remote Ports** with following configurations:
  - Remote Port 1: optical fiber interface (glass ST or plastic 1mm), electrical interface RS232 / RS232 FULL MODEM and RJ45 connector for ETHERNET communications.
  - Remote Port 2: optical fiber interface (glass ST or plastic 1mm), electrical interface RS232 / RS485 and RJ45 connector for ETHERNET communications.
  - Remote Port 3: optical fiber interface (glass ST or plastic 1mm), electrical interface RS232 / RS485 and RJ45 connector for ETHERNET communications.
- **2 LAN Ports** with following configurations (ETHERNET type communications):

	LAN 1	**LAN 2**
1st Combination	RJ45	RJ45
2nd Combination	RJ45	MTRJ
3rd Combination	FOC ST	FOC ST

- **1 Remote Port** with CAN protocol BUS connection.

Technical data for these communications links can be found in Chapter 2.1 (Technical Data). Information on model ports can be found in chapter 1.5 (Model selection).

3.32.2 Communication with the *ZIVercomPlus*®

Communication for configuring the protection, for loading or reading the configuration of the programmable logic and for obtaining the data protection (events, fault reports, oscillography, etc.) can be made through the communication ports that have the PROCOME protocol configured. The local port is always assigned this protocol, while the remote ports depend on the settings.

The communication is performed with the ***ZIVercomPlus***® communications program. It dialogs with the **6IRV** family of equipment and other equipment, either locally (through a PC connected to the front port) or remotely (via rear communications ports with PROCOME protocol), about all programming, settings, recording, reports, etc.

The local and remote communication ports are configured through the HMI.

The **6IRV** model has three controllers, one for each remote communication port, to allow establishing communication through all of them at the same time.

The ***ZIVercomPlus***® communications program, which covers the needs of this family of equipment, is password-protected against unauthorized users. The ***ZIVercomPlus***®, which runs under WINDOWS™, is user-friendly. The various submenus are opened with buttons or keys.

3.32.3 IRIG-B 123 and 003 Synchronization

6IRV models come with a **BNC** type input for synchronizing by means of a standard format **IRIG-B 123** or **003** time code signal. This input is located on the rear of the IED. The synchronization accuracy is ±1 ms.

If the **6IRV** IED is receiving **IRIG-B** signal for synchronization, the HMI will deny access to the **Date** and **Time** settings.

An output can be configured to indicate the reception status of the **IRIG-B** signal. This output will stay active as long as the unit receives this signal properly.

6IRV IEDs are also prepared to indicate the loss as well as the recovery of the **IRIG-B** signal by generating the events associated with each of these circumstances.

3.32.3.a UTC / Local Time Configuration

Discerning whether the time received through BNC connector corresponds to **UTC Time** or a given **Time Zone (Local)** is possible through **IRIG-B Time Zone** setting.

In the first case, a correction must be introduced to adapt the UTC time to the time zone of the relay site. The **Local Time Zone** setting within the **Date and Time** settings group is used for this purpose, which allows putting UTC time forward or back as required.

In the second case, the relay receives the time signal already adapted to the local time zone and no correction is needed. In this case local **Local Time Zone** has no effect.

3.32.3.b IRIG-B Function Settings

IRIG-B Function Settings			
Setting	**Range**	**Step**	**By Default**
IRIG-B Time Zone	0 = Local Time 1 = UTC Time	1	0 = Local Time

3.32.3.c Digital Outputs and Events of the IRIG-B Function

Table 3.32-1: Digital Outputs and Events of the IRIG-B Function		
Name	**Description**	**Function**
SIGNAL_IRIGB	IRIG B Active	Signal indicating reception of IRIG-B.

3.32.4 Communications Protocol

All **6IRV** relays are provided with rear communications ports for remote access and one front port for local access. Depending on model, rear ports feature several communications protocols:

- **Local Port**: uses only PROCOME protocol.
- **Remote Ports 1** and **2**: options PROCOME, DNP3.0, MODBUS and Virtual Inputs / Outputs are available.
- **Remote Port 3**: options PROCOME, DNP3.0 and MODBUS are available.
- **Remote Port 4**: options CAN and CAN MULTI-MASTER are available.
- **Ports LAN 1 and 2**: Can communicate with IEC61850 and PROCOME and, DNP3 and Modbus depending on model. Refer to IEC61850 communications section.

It is worth mentioning that communications through all ports can be maintained simultaneously.

PROCOME protocol complies with IEC-870-5 standards and is used, the same as for IEC61850, for both protection and control information management. On the other hand, protocols DNP 3.0, CAN and MODBUS are used for control information management.

For more details on protocols refer to the applicable protocol paragraph.

3.32.4.a Control Change Recording

Depending on signals configured into the programmable logic through the ***ZIVercomPlus***® program, the different system events make changed-state signals to be written.

Different signal lists for PROCOME 3.0 and DNP 3.0 protocols can be configured through the programmable logic, saving changes into different and separate **6IRV** relay files for each of the communications ports. This implies that although the tail of changes of one port is emptied after collecting said information, the same information is available at the other port for collection through the allocated protocol, whether it is the same as for the first port or not.

Also, from the signals configured in PROCOME, DNP 3.0 or both, signals to be displayed through the HMI can be selected. They are also saved into separate files, so that even if tails of control changes of communications ports are emptied, the information is still available through HMI. Between 100 and 115 records are saved depending on their simultaneity.

Information on the Control Change Record is displayed from the HMI or pressing F1 key through **Information** option, the changes list view or delete options being available. If the view option is selected, the last change generated is always displayed (the most recent). Information is presented as follows:

AA/MM/DD|HH:MM:SS
000 text1 ☐ or ■
001 text2 ☐ or ■

AA/MM/DD|HH:MM:SS
000 text3 ☐ or ■
001 text4 ☐ or ■

Namely, events are grouped by "date" and "time". Then, in the following line, the milliseconds corresponding to each control change and the label defined through the ***ZIVercomPlus***® (maximum of 13 characters) are shown. And at the end of the line, a filled or blank square indicates ACTIVATION-ON (■) or DEACTIVATION-OFF (□) respectively. Default signal text labels are defined in input and output tables; in case of new signals generated into the programmable logic, said text must be defined. In any case, in order to use the names required by each user, the creation of a logic record card allocating a personalized name to every signal to be displayed is recommended.

The date and time stamp will be generated every time a new event occurs in it.

The MODBUS allows to display the actual value of the configured digital signals but do not record their changes.

3.32.5 Communications Settings

As the below described settings are independent for each port, they are grouped as follows: **Local Port**, **Remote Port 1**, **Remote Port 2**, **Remote Port 3**, **LAN1**, **LAN2** and **CAN**. Finally specific settings for each protocol are described.

Whenever communication is established through one of these ports, the following codes are displayed on relay alphanumeric HMI:

- **Local port**: **[PL]** code.
- **Remote port 1**, **Remote port 2**, **Remote port 3**: **[P1]**, **[P2]** and **[P3]** codes.
- **Remote ports LAN1** and **LAN 2**: no display on HMI.
- **Remote port CAN**: **[P4]** code.

These codes, in case of PROCOME 3.0 protocol, remain displayed during **Communications Password TimeOut** setting indicated in paragraph 3.31.4.d after the last communication carried out; in case of MODBUS, DNP V3.00 and CAN protocols, the message remains displayed for one minute after the last communication.

There are three timer settings, one for each communications port (**Communication Failure Time Indication**), which, no matter the assigned protocol, allow configuring the period without communication activity before generating the alarms (digital signals and events) **Communication Failure Port 0**, **1**, **2**, **3** and **CAN**.

3.32.5.a Local Port

The setting options of the local communications port are:

- **Baud Rate**: a value from **300 bauds** to **57600 bauds** can be chosen, default value being 38400 bauds.
- **Stop Bits**: **one** of two stop **bits** can be selected.
- **Parity**: **even**, **odd** or **no parity** (None) can be selected. No parity is configured by default.
- **Character Reception Time** (**0-60000 ms**): maximum time between characters allowed during the receiving of a message. The current message will be considered cancelled if it exceeds the set time between the reception of two characters.
- **Communication Failure Indication Time** (**0-600 s**.): maximum time between messages without indication of communication channel blocking.

3.32.5.b Remote Port 1

Remote Communications Port 1 has simultaneous fiber optic and electrical access RS232C/RS485. Access through RS232C has all the MODEM lines in format DB9. In light of these characteristics, the settings available for configuring this port are:

- **Baud Rate**, **Stop Bits**, **Parity** and **Character Reception Time**, the same as the local port.
- **Protocol**: protocol options are PROCOME 3.O, DNP 3.0, MODBUS and Virtual Inputs / Outputs. The default protocol is PROCOME.
- **Advanced Settings** to use the port's full-modem characteristics:

  1. Flow Control

  CTS Flow (NO / YES): it specifies whether the **Clear to Send** signal is monitored to control the data transmission flow. If the setting is YES and the CTS signal falls to "0," the transmission is suspended until the CTS signal resets.
  DSR Flow (NO / YES): it specifies whether the **Data Set Ready** signal is monitored to control the data transmission flow. If the setting is YES and the DSR signal falls to "0," the transmission is suspended until the DSR signal resets.
  DSR Sensitive (NO / YES): it specifies whether the communications port is sensitive to the state of the DSR signal. If the setting is YES, the communications driver ignores any byte received unless the DSR line is active.
  DTR Control (INACTIVE / ACTIVE / ENABLE SEND):
  Inactive: It sets the DTR control signal to permanently inactive.
  Active: It sets the DTR control signal to permanently active.
  Enable Send: The DTR signal remains active as long as the receiving of new characters is allowed.
  RTS Control (INACTIVE / ACTIVE / ENABLE SEND / SOL. SEND):
  Inactive: It sets the RTS control signal to permanently inactive.
  Active: It sets the RTS control signal to permanently active.
  Enable Send: The RTS signal remains active as long as the receiving of new characters is allowed.
  Solicit send: The RTS signal remains active as long as there are characters pending transmission.

  2. Time

  Transmission Time Factor (0-100 characters): Per-character time factor that determines when the transmission times out.
  Transmission Time Constant (0-60000 ms): Fixed time in seconds that is added to the per-character time factor and that determines when the transmission times out.

  3. Message modification

  Number of Zeros (0-255): Number of zeros to insert as preamble to each message.

  4. Collisions

  Type of collision (NO / ECHO / DCE):
  NO: Collision detection disabled.
  ECHO: A collision is considered to have occurred when the characters received do not coincide with those transmitted.
  DCD: A collision is considered to have occurred when the DCD line is activated.
  Number of Retries (0-3): Maximum number of retries in the transmission when collisions are detected.
  Minimum Time between Retries (0-60000 ms): Minimum time between retransmissions due to detection of collision.
  Maximum Time between Retries (0-60000 ms): Maximum time between retries due to detection of collision.

3.32.5.c Remote Ports 2 and 3

Remote ports 2 and 3 have fiber optic and electrical access RS232 / RS485. Available configuration settings for these ports are similar to the local port settings, and it is possible to select the communications protocol and a specific parameter for RS485 application. Thus, settings are:

- **Baud Rate, Stop Bits, Parity** and **Character Reception Time**.
- **Protocol**: Depending on model, PROCOME 3.0, DNP 3.0, MODBUS protocols and Virtual Inputs / Outputs (this last option is only available for remote port 2) can be selected. The default protocol is PROCOME.
- **·Advanced settings**:

  1. Operation Mode (RS232 / RS485): This setting allows selecting the operation mode of DB9 interface of remote port 2 or 3 as a RS232 port or RS485 port.

  2. Time

  Transmission Time Factor (0-100 characters): Per-character time factor which determines when the transmission ends by time-out.

  Transmission Time Constant (0-60000 ms): Fixed time in seconds that is added to the per-character time factor, and that determines when the transmission ends by time-out.

  Number of 485 Stop Bytes (0-4 bytes): It specifies the number of stop bytes between transmit and receive when the port is configured as RS485.

  3. Message modification

  Number of Zeros (0-255): Number of zeros to insert as preamble to each message.

  4. Collisions

  Type of Collision (NO / ECHO / DCE):

  NO: Collision detection disabled.

  ECHO: A collision is considered to have occurred when the characters received do not coincide with the characters transmitted.

  Number of Retries (0-3): Maximum number of retries in the transmission when collisions are detected.

  Minimum Time between Retries (0-60000 ms): Minimum time between retransmissions on collision detection.

  Maximum Time between Retries (0-60000 ms): Maximum time between retries on collision detection.

3.32.5.d Ethernet Remote Ports 1, 2 and 3

- **Protocol**: Depending on model, PROCOME 3.0, DNP 3.0, MODBUS protocols and Virtual Inputs / Outputs (this last option is only available for remote port 2) can be selected. The default protocol is PROCOME.
- **Ethernet**
  1. Enabling the Ethernet Port (YES-NO): enables (YES) or disables (NO) the Ethernet Port.
  2. IP Address (ddd.ddd.ddd.ddd): Ethernet device ID number.
  3. Net mask (128.000.000.000 – 255.255.255.254): number that indicates to the device what part of the IP address is the network number, and what part of the IP address corresponds to the device.
  4. Port Number (0 - 62235): number used to indicate the delivery route of the data received, to the destination device.
  5. Max. Time between Messages TCP (0-65 sec.): number of seconds between Keepalive packages - if zero then Keepalive packages were not sent. These Packages inform the server if a client is still present on the Ethernet Network.
  6. RX Car Time (0-60000 milliseconds): maximum time between characters allowed while receiving a message through the Ethernet. The message is timed out if the set time is exceeded between the receipt of two characters.
  7. Communication fault indication time (0-600 sec.): maximum time between messages via the Ethernet port before an indication that communications have stopped.

3.32.5.e Remote Port 4

Remote port 4 of BUS CAN has the following configuration settings available:

- **Baud Rate** (100, 125, 250, 500 and 100 Kbaud).
- **Trip Indication Time** (1 - 10sc).

3.32.5.f PROCOME 3.0 Protocol Settings

The configuration settings of the PROCOME 3.0 protocol are:

- **Relay Number** (**0-254**): it specifies the address of the **6IRV** relay (acting as RTU or Remote Terminal Unit) in relation to the rest of equipment that communicate with the same master station (**MTU** or Master Terminal Unit).
- **Communications Password Enable** (**YES-NO**): this setting allows to enable the access password function to establish communication with the relay through the rear port: YES means enabling the permission and **NO**, disabling.
- **Communications Password TimeOut** (**1-10 minutes**): this setting allows establishing a period of time for activating a communication blocking with the relay (whenever communication is via the rear port): if the set time expires with no activity taking place in the communications program, the system blocks, and the communication must be reinitiated.
- **Communications Password**: the communications password allows establishing a specific password to access communications with the relay through the rear port. This password must have 8 characters, which will be entered using the numerical keys and the key corresponding to a dot.

3.32.5.g DNP 3.0 Protocol Settings

The DNP 3.0 protocol configuration settings include the definition of:

- **Relay Number** (0-65519): it specifies the address of the **6IRV** relay (acting as RTU or Remote Terminal Unit) in relation to the rest of equipment that communicate with the same master station (MTU or Master Terminal Unit). The 0xFFF0 to 0xFFFF addresses are reserved for the Broadcast addresses.
- **T. Confirm TimeOut** (100-65535): it specifies the time lapse (in milliseconds) from the time the **6IRV** sends a message requesting the master to confirm the Application layer (Level 7), until this confirmation is considered lost. The **6IRV** requests confirmation of the Application Layer when it sends spontaneous (Unsolicited) messages or in response to requests for Class 1 or Class 2 Data. When this time expires, the message is retransmitted the number of times specified in the N. Retries parameter.
- **N. Retries** (0-65535): number of retries of the Application Layer (N7). The default value is 0 (zero), indicating that no retransmission will be attempted.
- **Master Number Unsolicited** (0-65535): it specifies the address of the master station (MTU or Master Terminal Unit) to which the **6IRV** relay will send spontaneous (Unsolicited) messages. It is used in combination with Enable Unsolicited parameter. Addresses 0xFFF0 to 0xFFFF are reserved for Broadcast addresses.
- **Enable Unsolicited** (YES/NO): enables (YES) or disables (NO) sending spontaneous messages (Unsolicited); it is used in combination with the MTU Number parameter. For the **6IRV** relay to begin sending spontaneous messages the master must also enable them with the Function Code FC = 20.
- **Unsolicited Start Enable** (YES/NO): enables (YES) or disables (NO) sending spontaneous start messages (Unsolicited after Restart); it is used in combination with the MTU Number parameter. For the **6IRV** relay to begin sending spontaneous start messages there is not need for the master to enable them.
- **Time Grouping Unsolicited** (**100-65535**): it specifies the time interval between the generation of a first event for an unsolicited message and the transmission of the message, with the purpose of grouping several events that may occur within this time interval in a single transmission message, in order not to saturate the communications line with multiple messages.
- **Sync. Interval** (**0-120 minutes**): it specifies the maximum time interval between two synchronizations. If no synchronization occurs within the interval, the need for synchronization is set in Internal Indication (IIN1-4 NEED TIME). This setting has no effect if the Sync. Interval is 0.
- **Unsolicited Start Activation** (YES/NO) (**6IRV-*2*-******** models): enables (YES) or disables (NO) sending Forced Unsolicited messages (for compatibility with versions pre DNP3-1998). When Unsolicited Start is activated, the **6IRV** relay begins to transmit the existing spontaneous messages without additional enabling by the level 2. For this setting to have effect Enable Unsolicited Start must be enabled.
- **DNP3 Revision** (STANDARD ZIV/2003) (**6IRV-*2*-******** models): indicates the DNP3 certification revision to use. STANDARD ZIV or 2003 (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03).
- **Measurement Transmission as Class 1** (YES/NO): enables (YES) or disables (NO) measurement transmission as Class 1.
- **Compression of Multiple Reading Response Messages** (YES/NO): enables (YES) or disables (NO) same fragment multiple object response to multiple request message.

Up to 64 measurements or analog magnitudes can be set for DNP3 transmission. Among them, up to 16 measurements can be set for transmission upon a change request.

To select the measurements to transmit upon a change request, enable the **DNP3 Measurement Change** control configuration option using ***Ziverlog***®.

The measurement change transmission is set through two parameters for each measurement: **Upper Limit** (in profile I relays) or **Maximum Value** (in profile II relays) setting values and the **Band** setting value set for that measurement. Up to 16 band values may be configured through ***ZivercomPlus***®, which will be associated to the measurements enabled for change transmission in the same sequence as they are ordered in ***Ziverlog***®. Namely: band value 000 will be assigned to the first measurement enabled for change transmission, 001 to the second, and so on up to the last measurement enabled, with the limit of 16. The band represents a percentage of the **Maximum Value**, so that when a measurement change exceeds that band, the measurement value is annotated to be sent as change. When the relay receives a measurement change request, it will send all changes annotated.

Analog changes will not be annotated for measurements with option **DNP3 Measurement Change** enabled but with the band set to 100%, or measurements with option **DNP3 Measurement Change** not enabled, they being deemed disabled for change transmission.

Additionally, these are other settings defined for the **DNP3 Profile II and Profile II Ethernet Protocols**:

- **Class for binary changes** (CLASS..., NONE). Assigns the class to the binary changes.
- **Class for analog changes** (CLASS..., NONE). Assigns the class to the analog changes.
- **Class for counter changes** (CLASS..., NONE). Assigns the class to the counter changes.
- **"Status" type binary inputs** (YES-NO). Binary inputs used are according to "status" type inputs (YES) or binary inputs used are not sent according to "status" type inputs (NO).
- **32 bits analog inputs** (YES-NO). Analog inputs used are 32 bits resolution (YES) or analog inputs used are 16 bits resolution (NO).
- Change in DNP3 Counter **(1 to 32767). The setting value shows the minimum increase of counts needed to send a new DNP3 message stating a new change in the counter. 20 counters can be configured as maximum under the DNP3 Profile II and Profile II Ethernet Protocols.**

3.32.5.h MODBUS Protocol Setting

The only configuration setting of the MODBUS protocol is the **IED Address** (0-254), which, as in the other protocols, specifies the address of the acting as RTU or Remote Terminal Unit for the rest of units communicating with the same master station (MTU or Master Terminal Unit).

3.32.5.i TCP/IP Protocol Settings

TCP/IP protocol configuration settings include the definition of:

- **Ethernet Channel 0** (**LAN 1**). The following settings are available within the channel:
  - IP Address (ddd.ddd.ddd.ddd).
  - DHCP Enable (YES/ NO).
  - Default Gateway (ddd.ddd.ddd.ddd).
  - Network Mask (ddd.ddd.ddd.ddd).
  - DNS Address (ddd.ddd.ddd.ddd).
- **Ethernet Channel 1** (**LAN 2**). The following settings are available within the channel:
  - IP Address (ddd.ddd.ddd.ddd).
  - DHCP Enable (YES/ NO).
  - Default Gateway (ddd.ddd.ddd.ddd).
  - Network Mask (ddd.ddd.ddd.ddd).
  - DNS Address (ddd.ddd.ddd.ddd).
- **SNTP** The following settings are available within SNTP:
  - SNTP enable (YES / NO)
  - Broadcast Synchronization Enable (YES / NO)
  - Unicast Synchronization Enable (YES / NO)
  - IP address of Primary SNTP Server (ddd.ddd.ddd.ddd).
  - IP address of Slave SNTP Server (ddd.ddd.ddd.ddd).
  - Unicast Validity Timer (10 - 1000000)
  - Unicast Error Timer (10 - 1000000)
  - Number of Connection Retries (1 - 10)
  - Tuning period (1 - 1000000)
  - Retry Period (1 - 1000000)
  - Broadcast validity Timer (0 - 1000000)
  - Broadcast Error Timer (0 - 1000000)
  - Maximum Synchronism Time Delay (0 - 1000000)
  - Ignore Synchronization Leap Indicator (YES / NO)
  - Synchronism State Calculation (Timing / Leap Indicator)

Settings related to the Ethernet Redundancy (depending on the model):

- **Redundancy mode** (No Redundancy / Bondng Redundancy / PRP Redundancy / RSTP Redundancy).
- **Channel status time** (1 - 60).
- **Bonding** Redundancy
  - Link check interval (25 - 500).
- **PRP** Redundancy
  - Transmission time of supervision frames (0 - 30000).
  - LSB of supervision frame destination MAC address (0 - 255).
- **RSTP** redundancy: settings are found in the web server. Refer to section Communications Protocol IEC61850.

3.32.6 IEC61850 Communications Protocol

3.32.6.a Introduction

IEC61850 communications equipment of the ‘V’ family is provided with functions additional to those provided by protection and control equipment.

This equipment may become independent from communications, performing their protection or control functions independently or may be used for data reports, set or receive specific data.

IEC61850 communications provide the following additional services:

- Report device-generated data (Starting, tripping, blocking, etc.) to higher level equipment (Central unit, remote control, HMI, etc.).
- Report prompt data (GOOSE) to other same level equipment (protections, control equipment, auxiliary services) or even to other higher level equipment.
- MMS communications that allows any MMS browser to receive the model of equipment data and be able to operate with it to edit settings and parameters and execute commands to the equipment.
- Handle a single configuration file (CID) that allows having a backup of all parameters whether they are protection, control and communications.
- Web server to provide data about equipment status, errors and state and measurement values.

3.32.6.b Starting Communications

Unlike protection and control functions that start in less than 3 seconds, **IEC61850** communications start in a variable time as a function of the data configured. In a reboot, the main **IEC61850** communications screens are as follows:

Initial moment in which the basic data of the operating system are loaded.

Starting IEC61850
06/08/11 02:98:36

Autorun screen that manages the IP and allows to stop booting or carry out other maintenance tasks.

AUTORUN 1.35 E(3.8)
LN1:192.168.1.81

Screens to create the **IEC61850** model and read **CID**.

READ CID
_6IRVA6S403B.CID

Equipment home screen that indicates the equipment is fully booted and ready for communications.

ZIV/6IRV
17/04/10 22:49:02

3.32.6.c Information Screens

Equipment with **IEC61850** communications include a data Menu, access of which is gained pressing the key combination: Up Scroll Arrow and Dot from the HMI default screen.

This screen displays in the first line the equipment software model, in the second line, versions of the active **IEC61850** application, the third, the equipment IP (if no network cable were connected, it will show 0.0.0.0) and the last line, the MAC of the network adapter.

6IRVA6S*403*B20FC**
V(0.7) [02] [6.0R]
192.168.1.81
00:E0:AB:02:98:36

From this screen more data can be displayed through the function keys F2, F3 and F4.

Pressing F2 displays a screen with Goose message data. This screen displays information on whether Goose message transmission is activated: [ON]GO, if receive is configured [ON]GI, and if so, the message that is not being received: 01??
The arrow → indicates the moment when a Goose message is sent.

[ON]GIe:0000 0000
01?? GIv:0000 0000
[ON]GOe:0000 0000→
GOv:0000 0000

Pressing F3 displays a screen with expanded data.

EBOOT (3.8)
[IRV-9836]
Ver SO(2.99)
IEC [6.0R][RUN]

It is a screen that can be scrolled down using the scroll arrows, the complete data being: Data on the Eboot, Operating System, application, checksums versions and network adapter data, etc.

```
EBOOT (3.8)
[IRV -9836]
Ver SO(2.99)
IEC [6.0R][RUN]
CRC:[4720E6D0]
BLD[Sep 28 2011]
BLD[08:46:05]
MMS<->IEC<->IRV
IRVP4N***403*K20FC
(0.7)[02]
[BOND_ETHBOND]
192.168.1.81
00:E0:AB:02:98:36
DHCP[0]
Type[6]
GWY[192.168.1.10]
CONNECTIONS 0

[BOND:ETHBOND]
RxERR:[0]
TxERR:[0]

FiFoE:0 Use:1
FiFoM:0 Use:68
NmRtr:0 Mxmed:4
```

Pressing F4 displays the SNTP client data screen. The screen shows the version of the Operating System, the version of the SNTP client, whether the client is switched off, switched on or in Error and the receive time and whether is valid (v) or invalid (i).

Ver S.O.(2.99)
Ver SNTP(2.250)
Sinc SNTP [ON]
10/04/17 22:49:02v

Press ESC to return to the default screen from any screen.

3.32.6.d Web Server

Through the web server access can be gained to firmware versions, boot status and useful relay data. Write the equipment IP address in a web browser for access:

The following data are displayed:

(C) ZIV http://www.ziv.es	
EBOOT	See (3.8) ID[IRV-9836]
Version NK	2.99
Version IEC	[6.2R][RUN]
Build EXE	[Sep 28 2011][4720E6D0]
Model IRV	6IRVA6S***403*B20FC
Version API	(0.6)[01]
HTML	APPLICATION
HTML	EXECUTION
HTML	MAPPING
HTML	CIDLOAD
	CONNECTIONS
	LIST DIGITALS
	LIST ANALOGS
	LIST OSCILOS
TXT	APLERROR.LOG
TXT	MAPERROR.LOG
TXT	EXECERROR.LOG
TXT	CIDERROR.LOG
CID ACTIVE	_DBCC1A612P.CID

ETHERNET ADAPTERS						
LAN2	**BOND_ETHBOND**	128.127.50.152	00:E0:AB:02:98:36	DHCP ON	Type[6]	GATEWAY:[128.127.0.102]

That corresponds to firmware versions, network adapter data, boot data, which can be displayed in web page (HTML) format or in downloadable text file (TXT) format.

Also, information on the active MMS connections (MMS clients), a list of internal signals and their value in IEC61850 standard format with their actual description is provided.

Generated oscillograms (DAT and CFG files) can be displayed and downloaded from the link.

Also, the active CID will be available, which can be downloaded from the link.

3.32.6.e Communications Port Configuration

Relays with IEC61850 communications use Ethernet network, using TCP/IP protocol for MMS communications (used to pack network data). Therefore, regardless of the physical medium and the connection (fiber, copper, etc.) the IP used by the relay in the network must be configured. For this, knowing the type of Ethernet redundancy implemented in each relay is vital, there being currently three possibilities:

- **No redundancy**

The relay is provided with 2 separate network adapters with different MAC address and different IP address. Both adapters are independent, it being possible to access the MMS data through both adapters. GOOSE messages will be sent and received only through one of the two adapters.

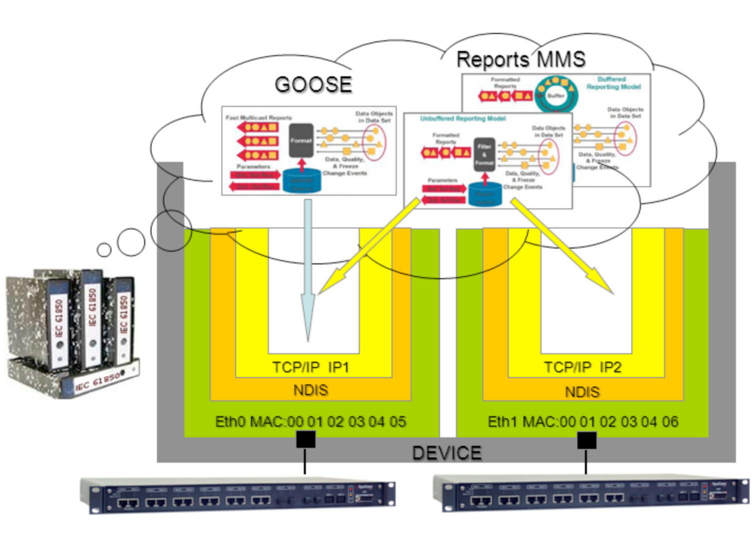


Figure 3.32.1 Configuration of Communications Ports for Relays without Ethernet Redundancy.

- **Bonding Type Redundancy**

The relay is provided with 2 network adapters both operating with the same MAC address and the same IP address, only one of them being active as a function of the medium detection (a broken connection to the adapter results in switching to the other adapter that has a good connection). Both MMS data and GOOSE messages will be sent and received only by the active adapter.

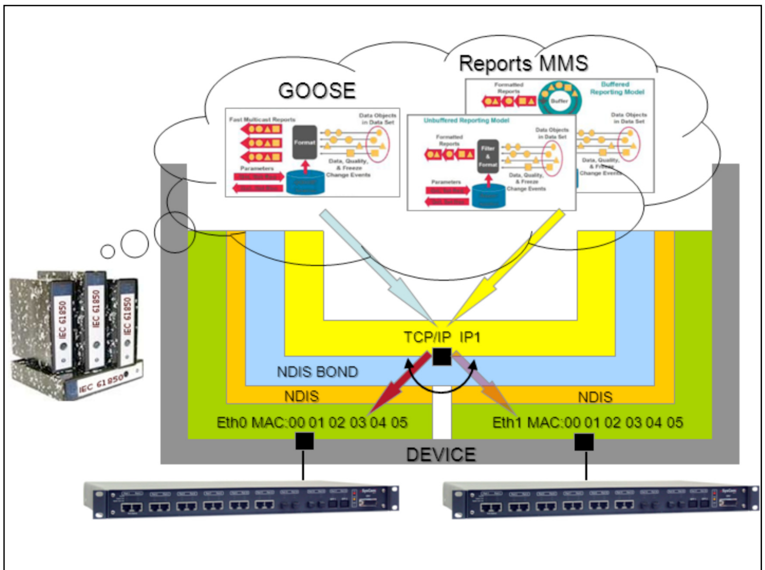


Figure 3.32.2 Configuration of Communications Ports for Relays with Bonding Type Redundancy.

- **PRP Type Redundancy**

The relay is provided with 2 network adapters both operating with the same MAC address and the same IP address, both adapters being active at any time and sending the same data through both adapters using the IEC 62439-3 protocol Parallel Redundancy Protocol (PRP).

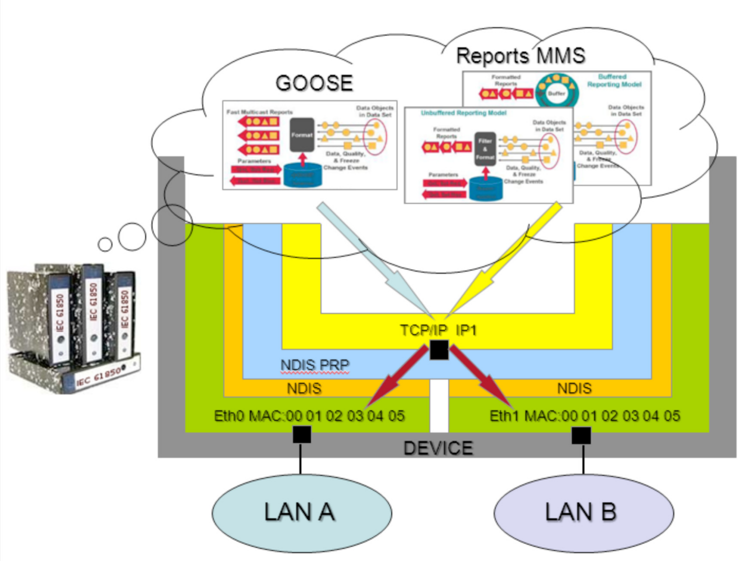


Figure 3.32.3 Configuration of Communications Ports for the Relay with PRP Type Redundancy.

This protocol is based on connecting the relays to two separate Ethernet networks (LAN), not connected to each other. The same data are sent through both adapters at the same time, adding 6 bytes to each Ethernet frame for the PRP protocol. These bytes enable discarding duplicate data, as the same data are received through both adapters and the idea is discarding the duplicate packet at the lowest possible level within the communications stack. The relay will send PRP supervision frames periodically (multicast) to enable system monitoring. Both MMS data and GOOSE messages will be sent through both adapters at the same time.

RSTP Type Redundancy

The relay includes 2 network adapters, both operating with the same MAC address and the same IP address, and both adapters are active at all times. Relays define, together, the optimal path to send messages opening the ring to prevent loop formation. Also, they reconfigure the path when some type of relay or link failure occurs.

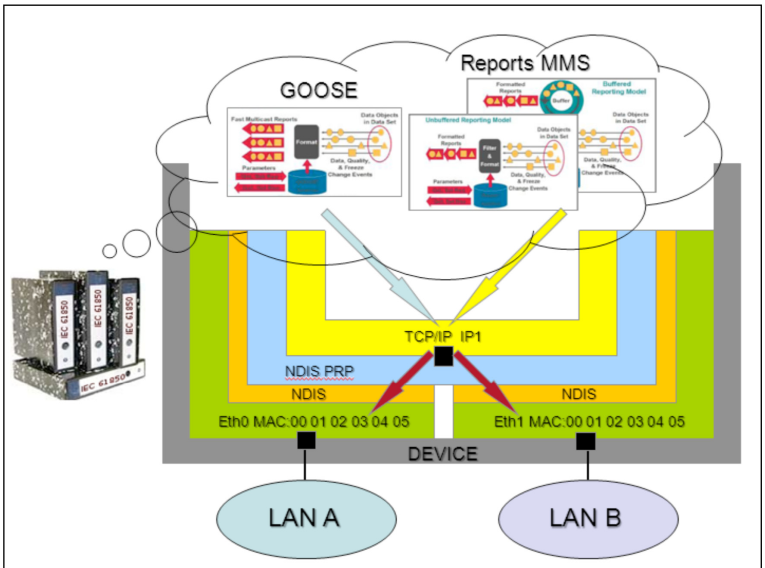


Figure 3.32.4 Configuration of Communications Ports for Relays with RSTP Type Redundancy

RSTP type redundancy is based on connecting relays with each other with single ring, star or star-ring instead of using switches. The relays themselves are in charge of defining and opening the ring, as well as deleting messages from the same preventing their indefinite recirculation.

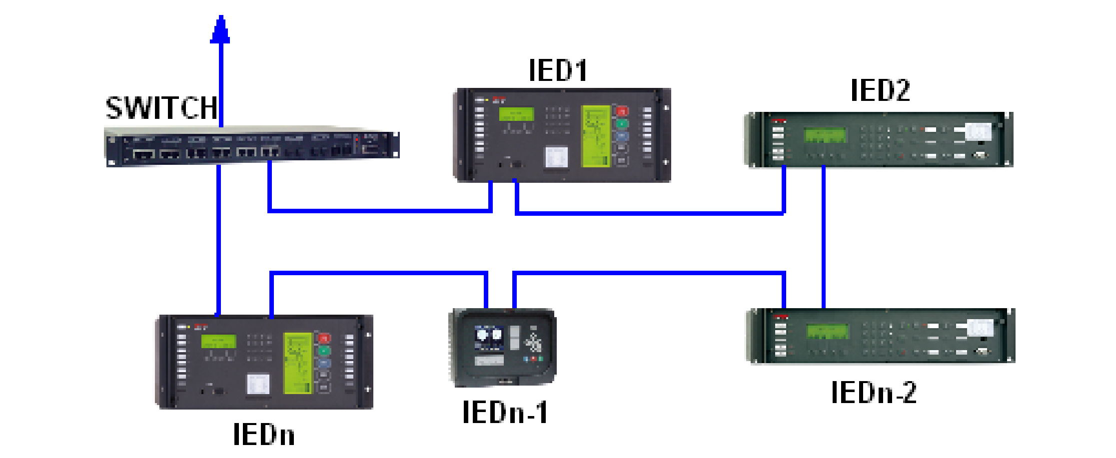


Figure 3.32.5 Example of Connecting Relays with RSTP Redundancy with Simple Ring

Relays **6IRV-*1**, **6IRV-*2** and **6IRV-*3** have no Ethernet redundancy, so they are provided with 2 physical ports with separate IPs, thus separate configuration settings. They will have the following settings per adapter:

- IP Address.
- DHCP Enable.
- Default Gateway.
- Network Mask.
- DNS Address.

6IRV-*0 Model settings are described below.

- **Goose Channel** (**Ethernet Channel 1** - **Ethernet Channel 2**): it selects the Goose message transmission / reception channel in IEC-61850.
- **Input Gooses**. The following settings are available within each IED:
  - **Subscription data**:
    Input Goose (from **1** to **32**):
    - Goose ID (Up to 65 characters): Input Goose identifier.
    - Goose CB ref (Up to 64 characters).
    - MAC Address (00.00.00.00.00.00 - FF.FF.FF.FF.FF.FF): Ethernet card address.
    - AppID (0 – 16383).
  - **Connections with Logic Inputs**:
    Logic Input Goose (from **1** to **32**):
    - Associated Goose: Input Goose from 1 to 32.
    - Object number (0 - 1024).
  - **Output Goose**.
    Goose Out Enable (YES / NO): it enables output Gooses.
    Goose Out ID (up to 65 characters): output Goose identifier.
    MAC Address (01.0C.CD.01.00.00 - 01.0C.CD.01.01.FF).
    Priority (0 -1).
    VID (0 - 4095).
    App. ID (0 - 16383).
    Revision (0 - 999999999).
    First Retry Timer (1 - 100 ms).
    Retry Time Multiplier (1 - 100).
    Maximum Retry Time (0.1 - 30 s).

6IRV-*2 and **6IRV-*3** relays do not include most of these settings, as they are used for Gooses configuration, configuration file IEC 61850 (**CID**).

The following settings can still be defined:

- **Goose Channel** (**Channel Ethernet 1** - **Channel Ethernet 2**): selects Goose message transmission / reception channel according to IEC-61850.
- **Output Goose**.
  - **Goose Out Enable**(YES / NO): enables output Gooses.

Relays **6IRV-*4** count on Bonding type redundancy, whereby they have 2 physical ports with only one IP with only one set of setting:

- IP Address.
- DHCP Enable.
- Default Gateway.
- Network Mask.
- DNS Address.

Since there is no setting to configure the GOOSE send / receive channel, as it always occurs through the active adapter, it incorporates only the following setting:

- **Output Goose**.
  - **Goose Out Enable** (YES / NO): it enables output Gooses.

It also includes a setting to configure the medium switching time (from 25 to 1000 ms).

Models **6IRV-*6** or higher implement different types of redundancy. They will have a setting to configure this mode of redundancy:

- If no redundancy is selected (**No Redundancy**), they will have 2 physical ports with separate IPs, thus, separate configuration settings. They will have the following settings per adapter:

○ IP Address.	○ Network Mask.
○ DHCP Enable.	○ DNS Address.
○ Default Gateway.	

The following settings can also be defined:

- **Goose Channel** (**Channel Ethernet 1** - **Channel Ethernet 2**): selects Goose message transmission / reception channel according to IEC-61850.
- **Output Goose**.
  - **Goose Out Enable**(YES / NO): enables output Gooses.

- If Bonding type redundancy is selected (**Bonding Redund.**), they will have 2 physical ports with only one IP and only one set of settings:

○ IP Address.	○ Network Mask.
○ DHCP Enable.	○ DNS Address.
○ Default Gateway.	

As there is no setting to configure the GOOSE send / receive channel, as it always is produced through the active adapter, they incorporate the following settings:

- **Output Goose**.
  - **Goose Out Enable**(YES / NO): enables output Gooses.
- **Channel Status Time Delay** (1 – 60 s): time without medium detection to indicate the channel is down.
- **Link Check Interval** (25 – 500 ms): time to determine that no medium is available switching to the other adapter.

- If PRP type redundancy is selected (**PRP Redund.**), it will have 2 physical ports with only one IP and only one set of settings:

○ IP Address.	○ Network Mask.
○ DHCP Enable.	○ DNS Address.
○ Default Gateway.	

As there is no setting to configure the GOOSE send / receive channel, as it is always produced through both adapters, they have the following settings:

- **Output Goose**.
  - **Goose Out Enable**(YES / NO): enables output Gooses.
- **Channel Status Time Delay** (1 - 60 s): time without receiving frames to indicate that the channel is down.
- **Transmission Time of Supervision Frames** (0 - 30000): send interval of PRP supervision frames.
- **LSB of Supervision Frame Destination MAC Address** (0 - 255): last octet of the PRP supervision frame destination MAC (destination MAC address will be 01-15-4E-00-01-XX).

- In case of **RSTP** type redundancy, the relay will be provided with 2 physical ports with only one IP and with only one set of settings as for Bonding type redundancy. All settings related to the switch, VLANes, priorities, etc., will be available through the web server from the moment when the relay setting is selected as **RSTP** and the relay has been booted. In this way, access can be gained to the settings below through the web server:

    - ***Version***: operation with protocol RSTP or STP.
    - ***Bridge Priority***: node priority.
    - ***Max Age***, ***Hello Time***, ***Forward Delay***: timers of the protocol RSTP itself (seconds).
    - ***Tx Hold Count***: maximum burst of messages sent per second.
    - For each port:
        - ***Priority***: priority.
        - ***Cost***: link cost.
        - ***Edge*** (On, Off, Auto): port with a host connected to it.
        - ***PtP*** (On, Off, Auto): point to point.
        - ***Edge Tx Filter***: deletion of Tx in case of an Edge port.

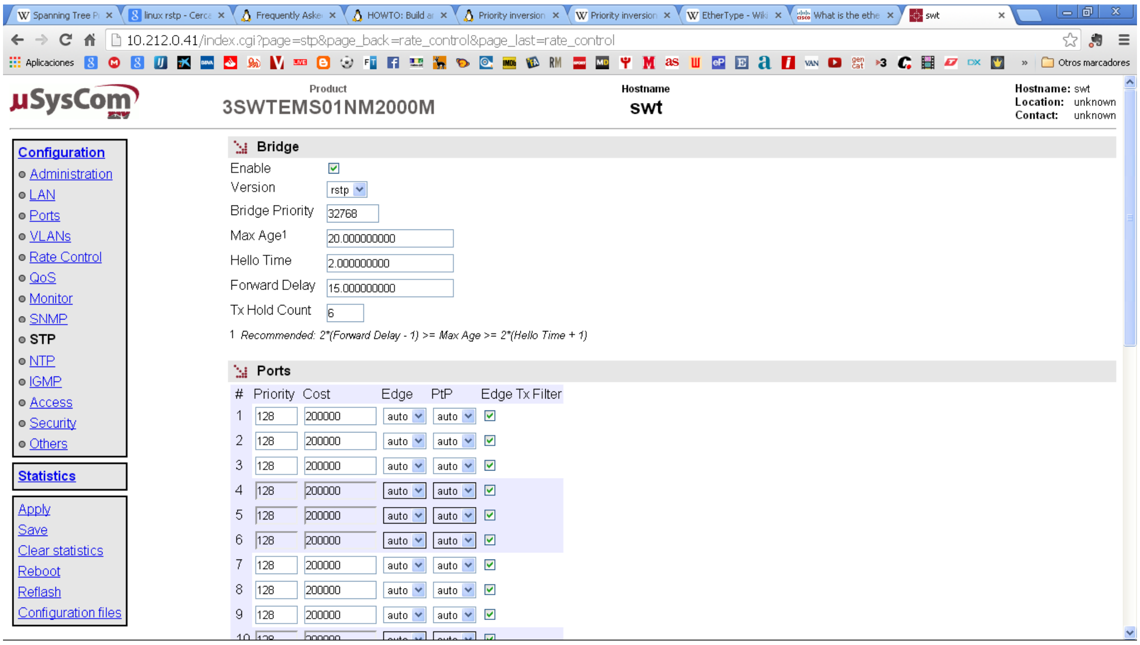


Figure 3.32.6 Image of the RSTP Settings available in the Web Server.

3.32.6.f FTP Access

The FTP access will allow having a number of equipment folders available. There will be different folders as a function of the user and password:

For IEC61850 versions previous tan the 7.7R, logging in as user: *info* and password: *info*, a directory structure similar to the one on the right will be displayed.

For IEC61850 versions equals or higher than the 7.7R the level of security has increased and a username and password to perform the loading of a CID and thus to change the control settings and protection settings will be necessary. In the same way, with the appropriate username and password, you can access to a directory in which you will only be able to copy a new CID (see Changing CID Configuration File section). For the user and password, please contact the manufacturer.

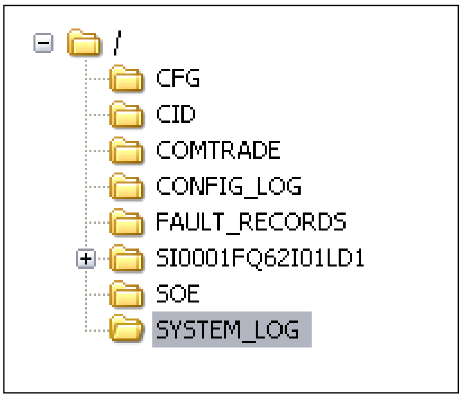


Figure 3.32.7 Directory Structure.

These are read-only folders and the information can be downloaded.

Directories will contain the same data provided by the web server: Boot data, active CID, oscillogram files, etc.

3.32.6.g CID Configuration File

The equipment includes a file (**CID**) in **IEC61850** standard format according to part 6 (SCL). This file allows knowing the equipment data model in node, data and attribute format.

Also, it allows to configure GOOSE message parameters, receive other GOOSES, create datasets and assign them to Reports, edit settings, change the control logic, descriptions, parameters, etc.

This file can be edited through a SCL file editing program, the ***ZiverCID***®.

This program allows configuring this file to be sent later to the equipment through FTP or USB port.

- ## Loading the CID trough FTP

In order to gain access to the equipment through FTP an FTP client program is required. The Windows browser itself allows making an FTP to the equipment address. For this, enter the equipment IP address in the Address bar in the following way:

For IEC61850 versions previous tan the 7.7R, the **CID** configured can be copied to the FTP root directory without entering user and password, as write access is gained only to the directory NotValidated. For IEC61850 versions higher than the 7.7R, the level of security has increased and a username and password to perform the action.

The equipment will validate the **CID**, that is, checks it is a correct SCL and the CID IP coincide with the IP configured in the equipment). After a certain version IEC61850 also checks that the IED matches the relay model that is within the CID.

Once it has been validated, the equipment carries out a backup and reboot process, rebooting communications and using a new **CID**. If the **CID** fails validation it will be rejected and deleted from the directory, and it will continue to operate in the normal way with the already loaded **CID** without ever losing communications.

If problems arise during loading the new **CID** (control reconfiguration process or loading protection settings), the relay will display a screen that will allow recovering the previous **CID** (refer to the errors section).

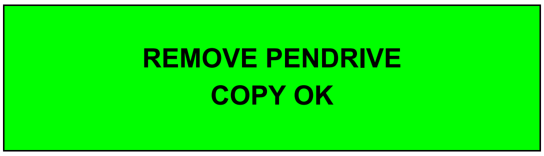
- ## Loading the CID through USB by means of a Pendrive

To load a new **CID** to the equipment through the HMI USB, an empty Pendrive is needed to copy the new CID to the root directory.

With the equipment fully booted and from the home screen, insert the Pendrive and wait for it to be detected.

Then confirmation to copy is requested.

Confirm by pressing F1.



When removing the Pendrive, the equipment will copy the **CID** to a temporary directory (NotValidated directory) where it will be validated (it will check it is a correct SCL and **CID** IP matches that of the equipment).

For versions higher than the 7.7R the level of security has increased and a password to perform the loading of a new CID will be necessary.

Once it has been validated, the equipment carries out a backup and reboot process, rebooting communications and using the new **CID**. If the **CID** fails validation it will be rejected and deleted from the directory, and it will continue to operate in the normal way with the already loaded **CID** without ever losing communications.

If problems arise during loading the new **CID** (control reconfiguration process or loading protection settings), the relay will display a screen that will allow recovering the previous **CID** (refer to the errors section).

If the USB contains more files or directories apart from the **CID,** the relay will display the message below, refusing to load:

REMOVE PENDRIVE
ONLY ONE FILE IN

- **Backup**

For a backup protection of the relay data, namely, obtaining the CID, logs, oscillograms and other data, the methods below can be used

- FTP with access as user: *info* and password: **info** (refer to FTP access section)
- Web server (refer to section)
- USB. With the relay booted and with no error messages displayed on the screen, insert an empty USB in the relay to automatically copy the active CID. Then, three screens will be displayed giving the user the option to download the rest of the data:

COPY OSCILOS
CONFIRM COPY
YES NO

COPY REPORTS
CONFIRM COPY
YES NO

COPY SYSLOGS
CONFIRM COPY
YES NO

CID Load by Frontal Port

CID file can be also loaded by the frontal serial port of the IED using the configuration tool ***ZIV e-NET TOOL*** (available depending on model selection).

- **Errors**

During equipment configuration, actions may be carried out resulting in errors that can be identified and corrected.

- **Switching the equipment off during the process of CID write to a Flash memory**: during operation, the equipment writes the CID to Flash type non volatile memory.

!WRITING CID!
DO NOT POWER OFF

  If during this process, the equipment is switched off, it is likely that the CID copied to the Flash is lost. In this case, in the next boot up the type of message below will be displayed on the screen, **_6IRVA6S104K.CID** being the active **CID** file.

IEC [6.0R]
!ERROR!:[0100]
_6IRVA6S104K.CID
YES RESTORE CID? NO

  For a few seconds, it will be possible to recover the backup copy of the **CID** available in the equipment just before the settings were last changed. The equipment will offer the same option after an incomplete attempt to load a new **CID**.

  If F1 is pressed to recover the **CID**, the equipment will use this backup copy to boot up. If F4 or no key is pressed, the equipment will remain waiting for a new CID through any of the **CID** loading methods (FTP or USB).

- **In case of multiple undue shutdowns** (e.g. shutdown after CID recovery), the backup copy of the CID could also be lost. In this case the message on the right will be displayed, waiting for a new **CID** to be introduced by any of the **CID** loading methods (FTP or USB).

IEC [6.0R]
!ERROR!:[0100]
-------.CID

- **100000 Alarm**. This means there is a problem with IEC61850 communications that does not affect the protection and control function.
  In this case, please contact the technical service to identify the nature of the failure.

ZIV/IRV
[ALARMS:00100000]
17/04/10 22:49:02

3.32.6.h Code Errors

- **HMI of the relay**

ERROR CODE	DESCRIPTION
0x00003010	General error generated while loading the Data Model of the relay. Reasons: the CID file does not match the relay model, the CID version does not match the FW version of the relay…
0x00003020	IDS does not match the relay model. Reason: the IEC 61850 FW relay model and version does not match the protection FW relay model and version.
0x00003060	Error in the GOOSE subscription configuration. Reason: there is any kind of error in the GIGGIO logical node (setRef or intAddr). Check the webser log, it indicates exactly where the problem is.
0x00003070	Error in RFC1006.CFG file. Reason: IEC 61850 FW error, this file belongs to the set of files of the FW and it is loaded to the relay when updating the FW.
0x00003080	Error in the interface version of the relay. Reason: IEC 61850 FW error.
0x00003011	Error when loading a new CID file. Reason: the control logic inside the CID file has any kind of error.
0x00003200	Error in IRQs of DPRAM. Reason: IEC 61850 and/or protection FW error.

- **Webserver**

TEXT	DESCRIPTION
ERROR_SUSGOOSE	Error in the GOOSE subscription configuration.
ERROR_CFGPERFIL	Error while loading the Data Model of the relay.
ERROR_CFGLOG	Error when asking for the information of the control logic which is loaded in the relay.
ERROR_MEMCFGLOG	Error when reserving memory for the control logic configuration.
ERROR_CFGLOGREAD	Error when reading the control logic nodes loaded.
ERROR_VER_PERFIL	Error in the compatibility of the profiles loaded.
ERROR_DB_REFNVL	Error in the generation of Data Sets.
ERROR_CFGERROR	Error while mapping the Data Model.
ERROR_CRC_PERFIL	Error in the CRC.
ERROR_OPENPERFIL	Error when opening the profile.
ERROR_RUN_SRVCOMPRESS	Error when executing the compression server.
ERROR_OPEN_CID	Error when opening or Reading the CID file.
ERROR_HEAD_CID	Error when reading the head of the CID file.
ERROR_IED_NAME_CID	Error when reading the IED name in the CID file.
ERROR_DATASET_ITEM_CID	Error when reading elements of a Data Set.
ERROR_RCB_CID	Error when reading the list of RCBs.
ERROR_GOOSE_ID_CID	Error when reading the elements of a GOOSE.
ERROR_READ_SP_CID	Error when reading the data of a SP.
ERROR_WRITE_SP_CID	Error when writing data of a SP.
ERROR_WRITE_PRM_REV_CID	Error when writing the ParamRev in the CID.
ERROR_IRV_RD_CID	Error when reading protection settings.
ERROR_IRV_WR_CID	Error when writing protection settings.
ERROR_HEAD_LOGICA	Error when reading data of the control logic from the CID.

TEXT	DESCRIPTION
ERROR_READ_CF_CID	Error when reading the CF values from CID.
ERROR_CACHE_CID	Error when generating the copy in RAM of the CID once uncompressed.
ERROR_CONNECT_AP_IP	Error when read in the IP address from CID.
ERROR_ATTR_IN_CID	There is one (or more) elements in one Data Set whose reference does not exist (it is located in no logical node).
ERROR_LCB_CID	Error when Reading data of LCB.
ERROR_CREATE_MAPLOG	Error when generating the MAPLOG.BIN file.
ERROR_READ_PRM_REV_CID	Error when Reading the ParamRev of the CID.
ERROR_GEN_LOG_CID	Error when generating the control logic.
ERROR_EXTRACT_LOG_CID	Error when extracting the files of the control logic.
ERROR_CONF_LOG_CID	Error in the control configuration loaded to the relay.
ERROR_APIXML_INIT	Error when initialization the XML library

3.32.6.i PROCOME, DNP3 and MODBUS Protocols on IEC-61850 Ports

6IRV-*-*******N** relays can communicate through LAN1 and LAN2 ports with IEC61850, PROCOME, MODBUS and DNP v3.0. TCP/IP ports for these communications links are allocated to the following values and cannot be configured:

- PROCOME: port 32001.
- MODBUS: port 502.
- DNP v3.0: port 20000.

This does not affect to the port selection for other physical ports (local port, remote ports 1-3).

6IRV-*-*******P** relays include five communications instances for other than IEC61850 protocols through LAN IEC61850 ports. One instance is always PROCOME (proprietary protocol) and the other four can be configured to communicate with DNP3.0 or MODBUS simultaneously (the same protocol can be selected for the four instances).

TCP/IP ports for these communications links will be configurable, except the proprietary protocol, PROCOME, which will have fixed TCP/IP port (32001).

This does not affect to the port selection for other physical ports (local port, remote ports 1-3).

3.32.7 CAN Communications Protocol

3.32.7.a Introduction

In view of the large number of signals acquired and controlled in power substations, remote real time device inputs and outputs must be connected via high speed serial communication protocols, so as to reduce the cost and simplify the hard wiring in the power substation environment.

The above is achieved through the communication of **ZIV** Master Relays with other Slave Relays using the CAN protocol, this way increasing the number of inputs and outputs available in **ZIV** Master Relays, said signals behaving as if they were internal to **ZIV** Master Relay.

3.32.7.b General Data

- **Physical Level**

Description	Value
Can Version	2.0b
Baud Rate	125 kbits
Bit Time	8 micro s
Maximum Distance	500 meters
Id Size	11 bits

When CAN 2.0b with 16 bit ID messages are transmitted the following bits corresponding to the extended CAN are sent:

- RTR to 1 (recessive)
- r0 to 1 (recessive)
- r1 1 0 (dominant)

All transmitted messages are acknowledged by writing one dominant bit of the first of the two recessive bits sent by the transmitter in the acknowledge field.

NRZ bits coding (Non-Return-to-Zero).

In data frames with 5 consecutive bits, a sixth bit with opposite sign is inserted.

CAN bus electrical characteristics are defined in ISO 11898.

- **Link Level**

It uses media access CSMA/CD+CR (Carrier Sense Multiple Access Collision Resolution).

- In Ethernet (CSMA), upon a collision, all messages are lost.
- In CAN (CSMA/CD+CR), upon a collision, the highest priority message survives (defined by dominant bits).

The state of a node can be Active, Passive or Cancelled as a function of errors detected.

- **Application Level**

The Application Layer uses an optimized protocol for power substation Protection and Control applications, with messages of 1 to 8 bytes.

Implemented protocol messages are used to achieve the following functions:

- **LOGIN Message**. Allows the **ZIV** Master Relay to know the availability of Slave Relays.
- **CHANGE Message**. Allows the **ZIV** Master Relay to receive spontaneously the state of Slave Relay inputs and outputs.
- **READ Message**. Allows the **ZIV** Master Relay to request the state of Slave Relay inputs and outputs.
- **TICK Message**. Allows the **ZIV** Master Relay to synchronize with Slave Relays.
- **DIGITAL OUTPUT WRITE Message**. Allows the **ZIV** Master Relay to send the state of digital outputs to Slave Relays.
- **SETTINGS WRITE Message**. Allows the **ZIV** Master Relay to send the Settings value to Slave Relays.

3.32.7.c Digital Inputs of the CAN Function

Table 3.32-2: Digital Inputs of the CAN Function

Name	Description	Function
RDO_1	Remote digital output 1	Activates said remote digital output in the CAN port.
RDO_2	Remote digital output 2	
RDO_3	Remote digital output 3	
RDO_4	Remote digital output 4	
RDO_5	Remote digital output 5	
RDO_6	Remote digital output 6	
RDO_7	Remote digital output 7	
RDO_8	Remote digital output 8	
RDO_9	Remote digital output 9	
RDO_10	Remote digital output 10	
RDO_11	Remote digital output 11	
RDO_12	Remote digital output 12	
RDO_13	Remote digital output 13	
RDO_14	Remote digital output 14	
RDO_15	Remote digital output 15	
RDO_16	Remote digital output 16	

3.32.7.d Auxiliary Outputs of the CAN Function

Table 3.32-3: Auxiliary Outputs of the CAN Function

Name	Description	Function
RIN_1	Remote digital input 1	Activates said remote digital input in the CAN port.
RIN_2	Remote digital input 2	
RIN_3	Remote digital input 3	
RIN_4	Remote digital input 4	
RIN_5	Remote digital input 5	
RIN_6	Remote digital input 6	
RIN_7	Remote digital input 7	
RIN_8	Remote digital input 8	
RIN_9	Remote digital input 9	
RIN_10	Remote digital input 10	
RIN_11	Remote digital input 11	
RIN_12	Remote digital input 12	
RIN_13	Remote digital input 13	
RIN_14	Remote digital input 14	
RIN_15	Remote digital input 15	
RIN_16	Remote digital input 16	
RIN_17	Remote digital input 17	
RIN_18	Remote digital input 18	
RIN_19	Remote digital input 19	
RIN_20	Remote digital input 20	
RIN_21	Remote digital input 21	
RIN_22	Remote digital input 22	
RIN_23	Remote digital input 23	
RIN_24	Remote digital input 24	
RIN_25	Remote digital input 25	
RIN_26	Remote digital input 26	
RIN_27	Remote digital input 27	
RIN_28	Remote digital input 28	
RIN_29	Remote digital input 29	
RIN_30	Remote digital input 30	
RIN_31	Remote digital input 31	
RIN_32	Remote digital input 32	

Table 3.32-3: Auxiliary Outputs of the CAN Function		
Name	**Description**	**Function**
VAL_RIN_1	Validity of remote digital input 1	Activates said validity of remote digital input.
VAL_RIN_2	Validity of remote digital input 2	
VAL_RIN_3	Validity of remote digital input 3	
VAL_RIN_4	Validity of remote digital input 4	
VAL_RIN_5	Validity of remote digital input 5	
VAL_RIN_6	Validity of remote digital input 6	
VAL_RIN_7	Validity of remote digital input 7	
VAL_RIN_8	Validity of remote digital input 8	
VAL_RIN_9	Validity of remote digital input 9	
VAL_RIN_10	Validity of remote digital input 10	
VAL_RIN_11	Validity of remote digital input 11	
VAL_RIN_12	Validity of remote digital input 12	
VAL_RIN_13	Validity of remote digital input 13	
VAL_RIN_14	Validity of remote digital input 14	
VAL_RIN_15	Validity of remote digital input 15	
VAL_RIN_16	Validity of remote digital input 16	
VAL_RIN_17	Validity of remote digital input 17	
VAL_RIN_18	Validity of remote digital input 18	
VAL_RIN_19	Validity of remote digital input 19	
VAL_RIN_20	Validity of remote digital input 20	
VAL_RIN_21	Validity of remote digital input 21	
VAL_RIN_22	Validity of remote digital input 22	
VAL_RIN_23	Validity of remote digital input 23	
VAL_RIN_24	Validity of remote digital input 24	
VAL_RIN_25	Validity of remote digital input 25	
VAL_RIN_26	Validity of remote digital input 26	
VAL_RIN_27	Validity of remote digital input 27	
VAL_RIN_28	Validity of remote digital input 28	
VAL_RIN_29	Validity of remote digital input 29	
VAL_RIN_30	Validity of remote digital input 30	
VAL_RIN_31	Validity of remote digital input 31	
VAL_RIN_32	Validity of remote digital input 32	
RDO_1	Remote digital output 1	Activates said remote digital output in the CAN port.
RDO_2	Remote digital output 2	
RDO_3	Remote digital output 3	
RDO_4	Remote digital output 4	
RDO_5	Remote digital output 5	

Table 3.32-3: Auxiliary Outputs of the CAN Function		
Name	**Description**	**Function**
RDO_6	Remote digital output 6	Activates said remote digital output in the CAN port.
RDO_7	Remote digital output 7	
RDO_8	Remote digital output 8	
RDO_9	Remote digital output 9	
RDO_10	Remote digital output 10	
RDO_11	Remote digital output 11	
RDO_12	Remote digital output 12	
RDO_13	Remote digital output 13	
RDO_14	Remote digital output 14	
RDO_15	Remote digital output 15	
RDO_16	Remote digital output 16	

3.32.8 Virtual Inputs / Outputs

Virtual inputs / outputs function allows the bidirectional transmission of up to 16 digital signals and 16 analog magnitudes between two **6IRV** relays connected through a digital communications system. Said function allows programming logic functions of local and remote information whether analog or digital.

Among the main applications of virtual inputs / outputs is the optimizing of teleprotection schemes: they reduce digital signal transfer time between terminals, give more security in said transfer, allow exchanging a greater number of signals, etc.

The exchange of information between relays is made through frames sent every 2 ms, which include 16 digital signals and ½ analog magnitude. It is apparent that the transmission speed of the 16 digital signals is very high, as they are considered high priority signals; so that they can be used within teleprotection schemes.

The virtual inputs / outputs function allows detecting communication failure that generate errors in the frame contents (some of which are corrected by using a redundancy code) or errors in the frame reception sequence. The number of errors detected is recorded by a counter that resets after the **Error Detection Period** time setting. There is an input exists to reset this counter.

Depending on the model, relay rear ports Remote 1 and Remote 2 can be configured as virtual inputs / outputs ports. To this end, **Protocol Selection** setting of this port must be set to Virtual Inputs / Outputs.

Once the protocol Virtual Inputs / Outputs has been selected for one of the ports, the relay ignores all settings associated to said port shown in the Communications field, and only the settings introduced into the Inputs / Outputs field are considered as settings of the port selected as virtual.

Virtual inputs and outputs are configured exactly the same as for digital inputs and outputs, through the programmable logic incorporated into the ***ZIVercomPlus***® program.

3.32.8.a Virtual Port 1

Virtual Port 1 settings:

- **Enable**: enables virtual inputs / outputs function for this port.
- **Baud Rate**: a value from 9600 to 115200 bauds can be selected, default value being 9600 bauds.
- **Error Detection Period**: time after which the communications error counter is reset.
- **Time Out**: time without receiving a complete frame before a communications error is generated.
- **CTS Flow** (NO / YES): it specifies whether the Clear To Send signal is monitored for data transmission flow control. If it set to YES and the CTS signal falls to "0", the transmission is interrupted until the CTS signal is reset.
- **DSR Flow** (NO / YES): it specifies whether the Data Set Ready signal is monitored for data transmission flow control. If it set to YES and the DSR signal falls to "0", the transmission is interrupted until the DSR signal is reset.
- **DSR Sensitive** (NO / YES): it specifies whether the communications port is sensitive to DSR signal state. If it is set to YES, the communications driver ignores any bit received unless the DSR line is active.
- **DTR Control** (INACTIVE / ACTIVE / ENABLE SEND):
  Inactive: It sets the DTR control signal to permanently inactive.
  Active: It sets the DTR control signal to permanently active.
  Enable Send: The DTR signal remains active as long as the receiving of new characters is allowed.
- **RTS Control** (INACTIVE / ACTIVE / ENABLE SEND / SOL. SEND):
  Inactive: It sets the RTS control signal to permanently inactive.
  Active: It sets the RTS control signal to permanently active.
  Enable Send: The RTS signal remains active as long as the receiving of new characters is allowed.
  Solicit Send: The RTS signal remains active as long as there are characters pending transmission.

3.32.8.b Virtual Port 2

Virtual port 2 settings:

- **Enable**: enables virtual inputs / outputs function for this port.
- **Baud Rate**: a value from 9600 to 115200 bauds can be selected, default value being 9600 bauds.
- **Error Detection Period**: time after which the communications error counter is reset.
- **Time Out**: time without receiving a complete frame before a communications error is generated.

3.32.8.c Virtual Measurements

Virtual magnitudes corresponding to rear ports Remote 1 and Remote 2 can also be configured in the Inputs / Outputs field, and any of the magnitudes calculated by the relay can be selected, including the magnitudes calculated into the programmable logic through the ***ZIVercomPlus***® program.

3.32.8.d Digital Inputs of the Virtual Inputs / Outputs Function

Table 3.32-4: Digital Inputs of the Virtual Inputs / Outputs Function

Name	Description	Function
RST_CO_ERR1	Error counter 1 reset	Activation of this input resets the communications error counter associated to port 1.
RST_CO_ERR2	Error counter 2 reset	Activation of this input resets the communications error counter associated to port 2.
OUT_VIR1_1	Virtual digital output_1 1	Activates said virtual digital output of port 1.
OUT_VIR1_2	Virtual digital output_1 2	
OUT_VIR1_3	Virtual digital output_1 3	
OUT_VIR1_4	Virtual digital output_1 4	
OUT_VIR1_5	Virtual digital output_1 5	
OUT_VIR1_6	Virtual digital output_1 6	
OUT_VIR1_7	Virtual digital output_1 7	
OUT_VIR1_8	Virtual digital output_1 8	
OUT_VIR1_9	Virtual digital output_1 9	
OUT_VIR1_10	Virtual digital output_1 10	
OUT_VIR1_11	Virtual digital output_1 11	
OUT_VIR1_12	Virtual digital output_1 12	
OUT_VIR1_13	Virtual digital output_1 13	
OUT_VIR1_14	Virtual digital output_1 14	
OUT_VIR1_15	Virtual digital output_1 15	
OUT_VIR1_16	Virtual digital output_1 16	
OUT_VIR2_1	Virtual digital output_2 1	Activates said virtual digital output of port 2.
OUT_VIR2_2	Virtual digital output_2 2	
OUT_VIR2_3	Virtual digital output_2 3	
OUT_VIR2_4	Virtual digital output_2 4	
OUT_VIR2_5	Virtual digital output_2 5	
OUT_VIR2_6	Virtual digital output_2 6	
OUT_VIR2_7	Virtual digital output_2 7	
OUT_VIR2_8	Virtual digital output_2 8	
OUT_VIR2_9	Virtual digital output_2 9	
OUT_VIR2_10	Virtual digital output_2 10	
OUT_VIR2_11	Virtual digital output_2 11	
OUT_VIR2_12	Virtual digital output_2 12	
OUT_VIR2_13	Virtual digital output_2 13	
OUT_VIR2_14	Virtual digital output_2 14	
OUT_VIR2_15	Virtual digital output_2 15	
OUT_VIR2_16	Virtual digital output_2 16	

3.32.8.e Auxiliary Outputs of the Virtual Inputs / Outputs Function

Table 3.32-5: Auxiliary Outputs of the Virtual Inputs / Outputs Function

Name	Description	Function
VAL_DI1	Validity of virtual digital inputs 1	
VAL_AI1	Validity of virtual analog inputs 1	
VAL_DI2	Validity of virtual digital inputs 2	
VAL_AI2	Validity of virtual analog inputs 2	
IN_VIR1_1	Virtual Digital Input_1 1	Shows that said virtual input of port 1 is activated.
IN_VIR1_2	Virtual Digital Input_1 2	
IN_VIR1_3	Virtual Digital Input_1 3	
IN_VIR1_4	Virtual Digital Input_1 4	
IN_VIR1_5	Virtual Digital Input_1 5	
IN_VIR1_6	Virtual Digital Input_1 6	
IN_VIR1_7	Virtual Digital Input_1 7	
IN_VIR1_8	Virtual Digital Input_1 8	
IN_VIR1_9	Virtual Digital Input_1 9	
IN_VIR1_10	Virtual Digital Input_1 10	
IN_VIR1_11	Virtual Digital Input_1 11	
IN_VIR1_12	Virtual Digital Input_1 12	
IN_VIR1_13	Virtual Digital Input_1 13	
IN_VIR1_14	Virtual Digital Input_1 14	
IN_VIR1_15	Virtual Digital Input_1 15	
IN_VIR1_16	Virtual Digital Input_1 16	
IN_VIR2_1	Virtual Digital Input_2 1	Shows that said virtual input of port 2 is activated.
IN_VIR2_2	Virtual Digital Input_2 2	
IN_VIR2_3	Virtual Digital Input_2 3	
IN_VIR2_4	Virtual Digital Input_2 4	
IN_VIR2_5	Virtual Digital Input_2 5	
IN_VIR2_6	Virtual Digital Input_2 6	
IN_VIR2_7	Virtual Digital Input_2 7	
IN_VIR2_8	Virtual Digital Input_2 8	
IN_VIR2_9	Virtual Digital Input_2 9	
IN_VIR2_10	Virtual Digital Input_2 10	
IN_VIR2_11	Virtual Digital Input_2 11	
IN_VIR2_12	Virtual Digital Input_2 12	
IN_VIR2_13	Virtual Digital Input_2 13	
IN_VIR2_14	Virtual Digital Input_2 14	
IN_VIR2_15	Virtual Digital Input_2 15	
IN_VIR2_16	Virtual Digital Input_2 16	
OUT_VIR1_1	Virtual digital output_1 1	Activates said virtual digital output of port 1.
OUT_VIR1_2	Virtual digital output_1 2	
OUT_VIR1_3	Virtual digital output_1 3	
OUT_VIR1_4	Virtual digital output_1 4	
OUT_VIR1_5	Virtual digital output_1 5	
OUT_VIR1_6	Virtual digital output_1 6	
OUT_VIR1_7	Virtual digital output_1 7	
OUT_VIR1_8	Virtual digital output_1 8	
OUT_VIR1_9	Virtual digital output_1 9	
OUT_VIR1_10	Virtual digital output_1 10	

Table 3.32-5: Auxiliary Outputs of the Virtual Inputs / Outputs Function		
Name	**Description**	**Function**
OUT_VIR1_11	Virtual digital output_1 11	Activates said virtual digital output of port 1.
OUT_VIR1_12	Virtual digital output_1 12	
OUT_VIR1_13	Virtual digital output_1 13	
OUT_VIR1_14	Virtual digital output_1 14	
OUT_VIR1_15	Virtual digital output_1 15	
OUT_VIR1_16	Virtual digital output_1 16	
OUT_VIR2_1	Virtual digital output_2 1	Activates said virtual digital output of port 2.
OUT_VIR2_2	Virtual digital output_2 2	
OUT_VIR2_3	Virtual digital output_2 3	
OUT_VIR2_4	Virtual digital output_2 4	
OUT_VIR2_5	Virtual digital output_2 5	
OUT_VIR2_6	Virtual digital output_2 6	
OUT_VIR2_7	Virtual digital output_2 7	
OUT_VIR2_8	Virtual digital output_2 8	
OUT_VIR2_9	Virtual digital output_2 9	
OUT_VIR2_10	Virtual digital output_2 10	
OUT_VIR2_11	Virtual digital output_2 11	
OUT_VIR2_12	Virtual digital output_2 12	
OUT_VIR2_13	Virtual digital output_2 13	
OUT_VIR2_14	Virtual digital output_2 14	
OUT_VIR2_15	Virtual digital output_2 15	
OUT_VIR2_16	Virtual digital output_2 16	

3.32.8.f Magnitudes of the Virtual Inputs / Outputs Function

Table 3.32-6: Magnitudes of the Virtual Inputs / Outputs Function		
Name	**Description**	**Units**
MV1 01	Virtual Quantity 1 for communication channel 1	Depend on the magnitude configurated
MV2 01	Virtual Quantity 2 for communication channel 1	Depend on the magnitude configurated
MV1 03	Virtual Quantity for communication channel 1	Depend on the magnitude configurated
MV1 04	Virtual Quantity 4 for communication channel 1	Depend on the magnitude configurated
MV1 05	Virtual Quantity 5 for communication channel 1	Depend on the magnitude configurated
MV1 06	Virtual Quantity 6 for communication channel 1	Depend on the magnitude configurated
MV1 07	Virtual Quantity 7 for communication channel 1	Depend on the magnitude configurated
MV1 08	Virtual Quantity for communication channel 1	Depend on the magnitude configurated
MV1 09	Virtual Quantity 9 for communication channel 1	Depend on the magnitude configurated
MV1 10	Virtual Quantity 10 for communication channel 1	Depend on the magnitude configurated
MV1 11	Virtual Quantity 11 for communication channel 1	Depend on the magnitude configurated
MV1 12	Virtual Quantity 12 for communication channel 1	Depend on the magnitude configurated
MV1 13	Virtual Quantity 13 for communication channel 1	Depend on the magnitude configurated
MV1 14	Virtual Quantity 14 for communication channel 1	Depend on the magnitude configurated
MV1 15	Virtual Quantity 15 for communication channel 1	Depend on the magnitude configurated
MV1 16	Virtual Quantity 16 for communication channel 1	Depend on the magnitude configurated
MV2 01	Virtual Quantity 1 for communication channel 2	Depend on the magnitude configurated
MV2 01	Virtual Quantity 2 for communication channel 2	Depend on the magnitude configurated
MV2 03	Virtual Quantity 3 for communication channel 2	Depend on the magnitude configurated
MV2 04	Virtual Quantity 4 for communication channel 2	Depend on the magnitude configurated
MV2 05	Virtual Quantity 5 for communication channel 2	Depend on the magnitude configurated
MV2 06	Virtual Quantity 6 for communication channel 2	Depend on the magnitude configurated
MV2 07	Virtual Quantity 7 for communication channel 2	Depend on the magnitude configurated
MV2 08	Virtual Quantity 8 for communication channel 2	Depend on the magnitude configurated
MV2 09	Virtual Quantity 9 for communication channel 2	Depend on the magnitude configurated

Table 3.32-6: Magnitudes of the Virtual Inputs / Outputs Function		
Name	**Description**	**Units**
MV2 10	Virtual Quantity 10 for communication channel 2	Depend on the magnitude configurated
MV2 11	Virtual Quantity 11 for communication channel 2	Depend on the magnitude configurated
MV2 12	Virtual Quantity 12 for communication channel 2	Depend on the magnitude configurated
MV2 13	Virtual Quantity 13 for communication channel 2	Depend on the magnitude configurated
MV2 14	Virtual Quantity 14 for communication channel 2	Depend on the magnitude configurated
MV2 15	Virtual Quantity 15 for communication channel 2	Depend on the magnitude configurated
MV2 16	Virtual Quantity 16 for communication channel 2	Depend on the magnitude configurated
N E FA 1	Cumulative number of fatal errors detected in analog frame in communication channel 1	
N E FA 2	Cumulative number of fatal errors detected in analog frame in communication channel 2	
N E FD 1	Cumulative number of fatal errors in communication channel 1	
N E FD 2	Cumulative number of fatal errors in communication channel 2	
N ERR C 1	Cumulative number of fatal errors detected and repaired in communication channel 1	
N ERR C 2	Cumulative number of fatal errors detected and repaired in communication channel 2	
ACUM ERR 1	Cumulative number of fatal errors detected in the last N seconds in communication channel 1	
ACUM ERR 2	Cumulative number of fatal errors detected in the last N seconds in communication channel 2	
T SIN ACT 1	Time without activity in communication channel 1	
T SIN ACT 2	Time without activity in communication channel 2	

3.32.9 Communications Settings

Local Port Communications			
Setting	**Range**	**Step**	**Default**
Baud Rate	300 - 38400 Baud		38400
Stop Bits	1 - 2		1
Parity	0: None 1: Even		0: None
RX Time Between Character	1 - 60000 ms	0.5 ms	40 ms
Communication Failure Indication Time	0 - 600 s	0.1 s	60 s

Remote Communications Port 1			
Setting	**Setting**	**Setting**	**Default**
Protocol Selection	0: PROCOME 1: DNP 3.0 2: MODBUS		0:PROCOME
Baud Rate	300 - 38400 Baud		38400 Baud
Stop Bits	1 - 2		1
Parity	0: None 1: Even 2: Odd		0: None
RX Time between Character	1 - 60000 ms	0.5 ms	40 ms
Communication Failure Indication Time	0 - 600 s	0.1 s	60 s
Advanced Settings			
Flow Control			
CTS Flow	0 (NO) - 1 (YES)		NO
DSR Flow	0 (NO) - 1 (YES)		NO
DSR Sensitive	0 (NO) - 1 (YES)		NO
DTR Control	0: Inactive 1: Active 2: Permit send		0: Inactive
RTS Control	0: Inactive 1: Active 2: Permit send 3: Solicit send		0: Inactive
Time			
Tx Time Factor	0 -100 characters	0.5	1
Tx Time Constant	0 - 60000 ms	1 ms	0 ms
Message Modification			
Number of Zeros	0 - 255	1	0
Collisions			
Type of Collision	0: NO 1: DCD 2: ECO		NO
Number of Retries	0 - 3	1	0
Minimum Retry Time	0 - 60000 ms	1 ms	0 ms
Maximum Retry Time	0 - 60000 ms	1 ms	0 ms

Remote Communications Port 2			
Setting	**Range**	**Step**	**Default**
Protocol Selection	0: Procome 1: DNP V3.0 2: Modbus		0: Procome
Baud Rate	300 - 38400 Baud		38400 Baud
Stop Bits	1 - 2		1
Parity	0: None 1: Even 2: Odd		0: None
RX Time Between Character	1 - 60000 ms	0,5 ms	40 ms
Communication Failure Indication Time	0 - 600 s	0,1 s	60 s
Advanced Settings			
Operation Mode	0: RS232 1: RS485		0: RS232
Time			
Tx Time Factor	0 -100 characters	0,5	1
Tx Time Constant	0 - 60000 ms	1 ms	0 ms
Number of 485 Stop Bytes	0 - 4 bytes	1 byte	0 bytes
Message Modification			
Number of Zeros	0 - 255	1	0
Collisions			
Type of Collision	0: NO 1: ECO		0: NO
Number of Retries	0 - 3	1	0
Minimum Retry Time	0 - 60000 ms	1 ms	0 ms
Maximum Retry Time	0 - 60000 ms	1 ms	0 ms

Remote Communications Port 1, 2 and 3 Ethernet			
Setting	**Range**	**Step**	**Default**
Protocol Selection	PROCOME DNP 3.0 MODBUS Virtual Inputs / Outputs (*)		PROCOME
Enabling the Ethernet Port	NO / YES		YES
IP Address	ddd. ddd. ddd. ddd		192.168.1.151(PR1) 192.168.1.61(PR2) 192.168.1.71(PR3)
Net Mask	128.000.000.000 - 255.255.255.254		255.255.255.0
Port Number	0 - 65535	1	20000
Max. Time between Messages TCP	0 - 65 s	1	30
RX Car. Time	0 - 60000 ms	0.5 ms	1 ms
Communication fault indication time	0 - 600 s	0.1 s	60 s

(*) The Virtual Inputs / Outputs function is only for the Remote Port 2.

Communications Protocols			
Setting	**Range**	**Step**	**Default**
PROCOME Protocol			
IED Address	0 - 254	1	0
Communications Password Enable	YES / NO		NO
Communications Password Timeout	1 - 10 min	1	10 min
Communications Password	8 characters		
DNP 3.0 Protocol			
IED Address	0 - 65519	1	1
T. Confirm Timeout	100 - 65535 ms	1	1000 ms
Max. Retries	0 - 65535	1	0
Enable Unsolicited	YES / NO		NO
Unsolicited Start Enable	YES / NO		
Unsolic. Master No.	0 - 65519	1	1
Unsolic. Grouping Time.	100 - 65535 ms	1	1000 ms
Sync Interval	0 - 120 min	1	0 min
Unsolicited Start Activation	YES / NO		
DNP 3.0 Revision	Standard ZIV / 2003		
DNP 3.0 Protocol: Measurements (16 Deadband Measurements Change)	0.01 - 100	0.01	100
DNP 3.0 Profile II Protocol: Measurements (16 Deadband Measurements Change)	0.0001 - 100	0.0001	100
Digital Changes Class (DNP 3.0 Profile II and Profile II Ethernet)	CLASS 1 CLASS 2 CLASS 3 NONE		CLASS 1
Analog Changes Class (DNP 3.0 Profile II and Profile II Ethernet)	CLASS 1 CLASS 2 CLASS 3 NONE		CLASS 2
Counters Changes Class (DNP 3.0 Profile II and Profile II Ethernet)	CLASS 1 CLASS 2 CLASS 3 NONE		CLASS 3
Validity Status for Digital Inputs (DNP 3.0 Profile II and Profile II Ethernet)	YES / NO		YES
32 Bits Measurements (DNP 3.0 Profile II and Profile II Ethernet)	YES / NO		YES
Counters (max. 20) (DNP 3.0 Profile II and Profile II Ethernet)	1 - 32767	1	1
MODBUS Protocol			
IED Address	0 - 247	1	1

Communications Protocols			
Setting	**Range**	**Step**	**Default**
IEC-61850 Protocol			
Goose Channel	Ethernet Channel 1 Ethernet Channel 2		Ethernet Channel 1
Input Gooses			
Subscription data			
Input Goose (from 1 to 32)			
Goose ID	Up to 65 characters		
Goose CB ref	Up to 64 characters		
MAC Address	00.00.00.00.00.00 – FF.FF.FF.FF.FF.FF		00.00.00.00.00.00
AppID	0 - 16383	1	0
Connections with Virtual Input Gooses			
Virtual Input Goose (from 1 to 32):			
Associated Goose	Input Goose from 1 to 32		
Object number	0 - 1024	1	0
Output Goose			
Goose Out Enable	YES / NO		
Goose Out ID	Up to 65 characters		
MAC Address	01.0C.CD.01.00.00 - 01.0C.CD.01.01.FF		01.0C.CD.01.00.C1
Priority	0 - 1	1	0
VID	0 - 4095	1	0
App. D	0 - 16383	1	0
Revision	0 - 999999999	1	0
First Retry Timer	1 - 100 ms	1	4
Retry Time Multiplier	1 - 100	1	2
Maximum Retry Time	0.1 - 30 sc	0.01	10
IP			
IP Address	ddd.ddd.ddd.ddd		
DHCP Enable	YES / NO		YES
Default Gateway	ddd.ddd.ddd.ddd		
Network Mask	ddd.ddd.ddd.ddd		
DNS Address	ddd.ddd.ddd.ddd		

Communications Protocols			
Setting	**Range**	**Step**	**Default**
IEC-61850 Protocol			
SNTP			
SNTP enable	YES / NO		NO
Broadcast Synchronizing Enable	YES / NO		NO
Unicast Synchronizing Enable	YES / NO		NO
IP Address of Main SNTP Server	Ddd.Ddd.Ddd.Ddd		
IP Address of Secondary SNTP Server	Ddd.Ddd.Ddd.Ddd		
Time Delay of Unicast Validation	10 - 1000000 S	1 S	30 S
Time Delay of Unicast Error	10 - 1000000 S	1 S	30 S
Number of Connection Retries	1 - 10	1	3
Synchronizing Period	10 - 1000000 S	1 S	10 S
Period between Retries	10 - 1000000 S	1 S	10 S
Time Delay of Broadcast Validation	0 - 1000000 S	1 S	0 S
Time Delay of Broadcast Error	0 - 1000000 S	1 S	0 S
Maximum Synchronizing Time Difference	0 - 1000000 S	1 S	0 S
Ignore Synchronizing Leap Indicator	YES / NO		NO
Calculation of Synchronizing Status	Time delay Leap Indicator		Time delay
Ethernet			
Redundancy Mode	No Redundancy Bondng Redund. PRP Redund. RSTP Redund.		No Redundancy
Channel Status Time	1 - 60 s	1 s	5 s
Bonding			
Link Check Interval	25 - 500 ms	25 ms	100 ms
PRP			
Supervision Frame Send Interval	0 - 30000 ms	500 ms	2000 ms
LSB of Destination MAC for Supervision Frames	0 - 255	1	0

- **Communications: HMI Access**

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - PORTS**
1 - OPERATIONS	1 - PASSWORDS	**1 - PROTOCOLS**
2 - CHANGE SETTINGS	**2 - COMMUNICATIONS**	
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	

Local Port

0 - PORTS	**0 - LOCAL PORT**	**0 - BAUDRATE**
1 - PROTOCOLS	1 - REMOTE PORT 1	**1 - STOP BITS**
	2 - REMOTE PORT 2	**2 - PARITY**
		3 - RX TIME BTW. CHAR
		4 - COMMS FAIL IND. TIME

Remote Port 1

0 - PORTS	0 - LOCAL PORT	**0 - PROTOCOL SELECT.**
1 - PROTOCOLS	**1 - REMOTE PORT 1**	**1 - BAUDRATE**
	2 - REMOTE PORT 2	**2 - STOP BITS**
		3 - PARITY
		4 - RX TIME BTW. CHAR
		5 - COMMS FAIL IND. TIME
		6 - ADVANCED SETTINGS

0 - PROTOCOL SELECT.	
1 - BAUDRATE	
2 - STOP BITS	
3 - PARITY	**0 - FLOW CONTROL**
4 - RX TIME BTW. CHAR	**1 - TIME**
5 - COMMS FAIL IND. TIME	**2 - MESSAGE MODIF.**
6 - ADVANCED SETTINGS	**3 - COLLITIONS**

Remote Port 2

0 - PORTS	0 - LOCAL PORT	**0 - PROTOCOL SELECT.**
1 - PROTOCOLS	1 - REMOTE PORT 1	**1 - BAUDRATE**
	2 - REMOTE PORT 2	**2 - STOP BITS**
		3 - PARITY
		4 - RX TIME BTW. CHAR
		5 - COMMS FAIL IND. TIME
		6 - STOP BYTES 485
		7 - ADVANCED SETTINGS

0 - PROTOCOL SELECT.	
1 - BAUDRATE	
2 - STOP BITS	
3 - PARITY	**0- FLOW CONTROL**
4 - RX TIME BTW. CHAR	**1 - OPERATING MOD**
5 - COMMS FAIL IND. TIME	**2 - TIME**
6 - STOP BYTES 485	**3 - MESSAGE MODIF.**
7 - ADVANCED SETTINGS	**4 - COLLITIONS**

Ports / Remote Ports 1, 2 and 3 Ethernet

0 - PORTS	0 - LOCAL PORT	
1 - PROTOCOLS	**1 - REMOTE PORT 1**	
	2 - REMOTE PORT 2	**0 - PROTOCOL SELECT.**
	3 - REMOTE PORT 3	**1 - UART**
	4 - IRIG-B	**2 - ETHERNET**

0 - PROTOCOL SELECT.	**0 - BAUDRATE**
1 - UART	**1 - STOP BITS**
2 - ETHERNET	**2 - PARITY**
	3 - RX TIME BTW. CHAR
	4 - COMMS FAIL IND. TIME
	5 - ADVANCED SETTINGS

0 - BAUDRATE	
1 - STOP BITS	
2 - PARITY	**0 - FLOW CONTROL**
3 - RX TIME BTW. CHAR	**1 - TIME**
4 - COMMS FAIL IND. TIME	**2 - MESSAGE MODIF.**
5 - ADVANCED SETTINGS	**3 - COLLITIONS**

0 - PROTOCOL SELECT.	**0 - ETHERNET PORT**
1 - UART	**1 - IP ADDRESS**
2 - ETHERNET	**2 - SUBNET MASK**
	3 - PORT NUMBER
	4 - KEEPALIVE TIME
	5 - RX TIME BTW. CHAR
	6 - COMMS FAIL IND. TIME

Protocols / Procome Protocol

0 - PORTS	**0 - PROCOME PROTOCOL**	**0 - UNIT NUMBER**
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	**1 - COMMS PASSW. ENABLE**
	2 - MODBUS PROTOCOL	**2 - COMMS PASSW. TIMEOUT**
	3 - IEC 61850	**3 - COMMS PASSW.**
	4 - TCP/IP	

Protocols / DNP 3.0 Protocol

0 - PORTS	0 - PROCOME PROTOCOL	**0 - RELAY NUMBER**
1 - PROTOCOLS	**1 - DNP 3.0 PROTOCOL**	**1 - T. CONFIRM TIMEOUT**
	2 - MODBUS PROTOCOL	**2 - MAX RETRIES**
	3 - IEC 61850	**3 - HAB. UNSOLICITED**
	4 - TCP/IP	**4 - UNSOL. PICKUP ACT.**
		5 - UNSOLIC. MASTER NO.
		6 - UNSOL. GROUPING TIME
		7 - SYNCR. INTERVAL
		8 - REV DNP 3.0
		9 - MEASURES

Protocols / DNP 3.0 Protocol (Profile II and Profile II Ethernet)

0 - PORTS	0 - PROCOME PROTOCOL	**0 - RELAY NUMBER**
1 - PROTOCOLS	**1 - DNP 3.0 PROTOCOL**	**1 - T. CONFIRM TIMEOUT**
	2 - MODBUS PROTOCOL	**2 - MAX RETRIES**
	3 - IEC 61850	**3 - HAB. UNSOLICITED**
	4 - TCP/IP	**4 - UNSOL. PICKUP ACT.**
		5 - UNSOLIC. MASTER NO.
		6 - UNSOL. GROUPING TIME
		7 - SYNCR. INTERVAL
		8 - REV DNP 3.0
		9 - DIGITAL CHANGES CLASS
		10 - ANAL. CHANGES CLASS
		11 - COUN. CHANGES CLASS
		12 - STATUS VALIDEZ ED
		13 - MEASURES 32 BITS
		14 - MEASURES
		15 - COUNTERS

Protocols / Modbus Protocol

0 - PORTS	0 - PROCOME PROTOCOL	
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	
	2 - MODBUS PROTOCOL	**0 - UNIT NUMBER**
	3 - IEC 61850	
	4 - TCP/IP	

Protocols / IEC 61850 Protocol

0 - PORTS	0 - PROCOME PROTOCOL	
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	
	2 - MODBUS PROTOCOL	**0 - GOOSE CHANNEL**
	3 - IEC 61850	**1 - ENBLGOOSEOUT**
	4 - TCP/IP	

Protocols / TCP/IP Protocol

0 - PORTS	0 - PROCOME PROTOCOL	
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	
	2 - MODBUS PROTOCOL	**0 - LAN 1**
	3 - IEC 61850	**1 - LAN 2**
	4 - TCP/IP	**2 - SNTP**

0 - PROCOME PROTOCOL		**0 - IP ADDRESS**
1 - DNP 3.0 PROTOCOL		**1 - ENABLE DHCP**
2 - MODBUS PROTOCOL	**0 - LAN 1**	**2 - DEFAULT GATEWAY**
3 - IEC 61850	**1 - LAN 2**	**3 - NETWORK MASK**
4 - TCP/IP	2 - SNTP	**4 - DNS ADDRESS**

0 - PROCOME PROTOCOL		**0 - ENABLESNTP**
1 - DNP 3.0 PROTOCOL		**1 - ENBL_BROADCASTSNTP**
2 - MODBUS PROTOCOL	0 - LAN 1	**2 - ENBL_UNICASTSNTP**
3 - IEC 61850	1 - LAN 2	**3 - MAINSNTPSRV**
4 - TCP/IP	**2 - SNTP**	**4 - BACKUPSNTPSRV**
		5 - UNICAST VALID TIME
		6 - UNICAST ERROR TIME
		7 - RETRY ATTEMPTS
		8 - SYNC PERIOD
		9 - RETRY PERIOD
		10 - BRDCST VALID TIME
		11 - BRDCST ERROR TIME
		12 - MAX TIME DIF
		13 - SNTP_IGNORELEAPIND
		14 - SNTP_SYNCSTATECALC

Protocols / IEC 61850 Protocol (6IRV-*6)

0 - PORTS	0 - PROCOME PROTOCOL	**0 - ETHERNET**
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	**1 - IP**
	2 - MODBUS PROTOCOL	**2 - GOOSE**
	3 - IEC 61850	**3 - SNTP**

0 - ETHERNET	**0 - REDUNDANCY MODE**	
1 - IP	**1 - CHANNEL LIVE TIME**	
2 - GOOSE	**2 - BONDING**	
3 - SNTP	**3 - PRP**	

0 - ETHERNET	0 - REDUNDANCY MODE	
1 - IP	1 - CHANNEL LIVE TIME	
2 - GOOSE	**2 - BONDING**	**0 - LINK CHK INTERVAL**
3 - SNTP	3 - PRP	

0 - ETHERNET	0 - REDUNDANCY MODE	
1 - IP	1 - CHANNEL LIVE TIME	
2 - GOOSE	2 - BONDING	**0 - SUPERV TX INTERVAL**
3 - SNTP	**3 - PRP**	**1 - SUP LSB DEST MAC**

0 - ETHERNET		**0 - IP ADDRESS**
1 - IP	**0 - LAN 1**	**1 - ENABLE DHCP**
2 - GOOSE	**1 - LAN 2**	**2 - DEFAULT GATEWAY**
3 - SNTP		**3 - NETWORK MASK**
		4 - DNS ADDRESS

0 - ETHERNET	
1 - IP	**0 - GOOSE CHANNEL**
2 - GOOSE	**1 - ENBLGOOSEOUT**
3 - SNTP	

0 - ETHERNET	**0 - ENABLESNTP**
1 - IP	**1 - ENBL_BROADCASTSNTP**
2 - GOOSE	**2 - ENBL_UNICASTSNTP**
3 - SNTP	**3 - MAINSNTPSRV**
	4 - BACKUPSNTPSRV
	5 - UNICAST VALID TIME
	6 - UNICAST ERROR TIME
	7 - RETRY ATTEMPTS
	8 - SYNC PERIOD
	9 - RETRY PERIOD
	10 - BRDCST VALID TIME
	11 - BRDCST ERROR TIME
	12 - MAX TIME DIF
	13 - SNTP_IGNORELEAPIND
	14 - SNTP_SYNCSTATECALC

3.32.10 Outputs and Events of the Communications Module (6IRV-*6)

<table>
<tr><th colspan="3">Table 3.32-7: Outputs and Events of the Communications Module (6IRV-*6)</th></tr>
<tr><th>Name</th><th>Description</th><th>Function</th></tr>
<tr><td>RESET REQ</td><td>Reset Required for Reconfiguration</td><td>Indicates that it is necessary to reset the relay in order for the configuration changes to take effect.</td></tr>
<tr><td>WRITING FLASH</td><td>Writing to Flash in Progress</td><td>Indicates that a write to FLASH is in progress (ON: In progress / OFF: End).</td></tr>
<tr><td>SNTP NO SYNC</td><td>SNTP Not Synchronized</td><td>Indicates the synchronizing status of the SNTP module. (ON: Not Synchronized / OFF: Synchronized).</td></tr>
<tr><td>LAN1 STATUS</td><td>LAN1 Communications Port Status</td><td rowspan="2">Indicates the status of the applicable communications port LAN. It is only used when the relay is redundancy configured, whether bonding or PRP (if there is no redundancy, the value is always OFF):
- Bonding: Indicates whether LAN detects medium during a settable time. If medium is not detected during this time, it takes the value OFF. As soon as it detects medium, it switches to ON.
- PRP: Indicates whether LAN receives frames during a settable time. If it receives any frame, it takes the value ON. If no frames are received during this time, it takes the value OFF.</td></tr>
<tr><td>LAN2 STATUS</td><td>LAN2 Communications Port Status</td></tr>
<tr><td>BOND ACT LAN</td><td>Active LAN Communications Port (bonding)</td><td>Indicates the active LAN when the configured redundancy is bonding (OFF: LAN1 active / ON: LAN2 active).</td></tr>
<tr><td>LAN1 NET OVFL</td><td>Network Congestion Detected on LAN1</td><td rowspan="2">Indicates whether a network congestion is taking place (abnormal network avalanche) in the corresponding LAN (ON: Congestion present / OFF: No congestion present).</td></tr>
<tr><td>LAN2 NET OVFL</td><td>Network Congestion Detected on LAN2</td></tr>
</table>

3.32.11 Communications Test

In order to proceed with the communications testing the relay must be supplied with the nominal voltage. Then the “In Service” LED must light up.

3.32.11.a PROCOME Protocol Test

The testing shall be performed through the three communications ports (one front and two rear [P1 and P2] ports), which must be set as follows:

Baud rate	**38,400 bauds**
Stop bits	**1**
Parity	**1** (even)

All ports shall be assigned the PROCOME protocol in order to use the ***ZivercomPlus***® communications program in all of them.

Connect with the relay through the front port via a male DB9 cable. Synchronize the time through the ***ZivercomPlus***® program. Disconnect the relay and wait for two minutes. Then, supply power to the relay again and connect with the relay through both rear ports. Finally set the ***ZivercomPlus***® program to cyclic and check that the time updates properly with both P1 and P2 connected.

3.32.11.b DNP v3.0 Protocol Tests

The main objects to test are:

1	0	Binary Input – All variations
1	1	Binary Input

The relay is asked about the state in that instant of the IED's status contact input signals (digital inputs, digital outputs, logic signals) configured to be sent via DNP v3.0.

2	0	Binary Input Change – All variations
2	1	Binary Input Change without Time
2	2	Binary Input Change with Time
2	3	Binary Input Change with Relative Time

The relay is asked about the control changes generated by the status contact input signals configured to be sent via DNP v3.0. They can be all the changes, without time, with time or with relative time.

10	0	Binary Outputs – All variations

The relay is asked about the state of the writings of outputs configured in the relay.

12	1	Control Relay Output Block

The operations sent through communications are tested on the IED.

20	0	Binary Counter – All variations
20	1	32-bit Binary Counter
21	0	Frozen Counter – All variations
21	1	32-bit Frozen Counter
22	0	Counter Change Event – All variations

A request is made for the value of the counters included in the IED's logic. These counters can be 32-bits binary or frozen counters. A request is also made for the changes generated by the value of these counters.

30	0	Analog Input – All variations
30	2	16-Bit Analog Input

A request is made for the value of the IED's analog inputs at that precise moment.

32	0	Analog Change Event – All variations
32	4	16-Bit Analog Change Event with Time

A request is made for the control changes generated by the variation in the value of the IED's analog channels.

40	0	Analog Output Status – All variations

The relay is asked about the state at that precise moment of the value of the IED's analog outputs.

41	2	16-Bit Analog Output Block

The relay is asked about the state at that precise moment of the value of the IED's 16-bit analog outputs.

50	1	Time and Date

The IED's date and time are synchronized.

52	2	Time Delay Fine

The relay is asked about the communications delay time. It is measured from the time the relay receives the first bit of the first byte of the question until the transmission of the first bit of the first byte of the IED's response.

60	1	Class 0 Data
60	2	Class 1 Data
60	3	Class 2 Data
60	4	Class 3 Data

The relay is asked about the various data defined in the relay as Class 0, Class 1, Class 2 and Class 3.

Within these requests, the IED's generation and sending of Unsolicited Messages for each of the different kinds of data is tested.

80	1	Internal Indications

The IED's Internal Indication bit (IIN1-7 bit Device Restart) is reset.

--	--	No Object (Cold Start)

When the IED receives a “Cold Load Pickup” object, it must answer with a message object “Time Delay Fine” and with a reset of the internal indication bit IIN1-7 (Device Restart).

--	--	No Object (Warm Start)

When the IED receives a “Warm Load Pickup” object, it must answer with a message object “Time Delay Fine” and with a reset of the internal indication bit IIN1-7 (Device Restart).

--	--	No Object (Delay Measurement)

The IED must answer with a communications object “Time Delay Fine.”

The Broadcast addresses are tested and the indications corresponding to “All Stations” with each of them.

3.33 Adaptive Sampling Frequency

3.33.1 Description

6IRV relays include an algorithm that automatically adapts the sampling frequency to the network frequency, varying the time between samples, to ensure that the DFT calculation window comprises exactly one network cycle. If this adaptation should not take place, said window would not comprise one periodic wave, which will result in DFT measurement errors. The greater the deviation between the window time and the period of the sampled wave, the greater the errors.

The algorithm of sampling frequency adaptation is disabled by default. It can only be enabled through the HMI, which is only recommended in those cases in which large variations in the frequency are likely to be produced. For this, go to option **2-Change Settings→8- Digital PLL**.

3.33.2 Digital PLL Settings

Digital PLL			
Setting	**Range**	**Step**	**By Default**
Enable	YES / NO		NO

3.33.3 Digital Inputs and Events of the Digital PLL

Table 3.33-1: Digital Inputs and Events of the Digital PLL		
Nombre	**Descripción**	**Función**
ENBL_PLL	Digital PLL Enable Input	It enables the operation of the automatic frequency adaptation system. It is set to logic “1” by default.

3.34 Current Transformers Dimensioning

3.34.1 Introduction

When dimensioning the Current Transformers (CTs), several factors are taken into account that influence the level of flux generated in the CT itself and, therefore, the tendency of the same to saturate. These include: load, internal resistance, incidence angle of the fault, primary and secondary time constants, remanence, etc.

The following points describe the data provided by different CT standards and the factors that must be calculated for the CT dimensioning

3.34.2 CT Dimensioning According to Different Standards

3.34.2.a Class P of IEC 61869-2 Standard

The CT is specified with the following data:

- Rated transformation ratio: the ratio of the rated primary current to the rated secondary current, e.g 600/5.
- Rated power: power provided by the CT at rated current and rated burden, e.g 10 VA.
- Accuracy class: 5P and 10P defines a maximum composite error of 5% or 10% at the accuracy limit current (accuracy limit factor (ALF) multiplied by the rated current).
- Accuracy limit factor: times the rated current, without DC offset, at which the accuracy class is fulfilled.
- Secondary internal resistance.

The CT will be adequate if K_total=Kssc*Kb*Ktf*Krem<ALF, where

Kssc: symmetrical short-circuit current factor.
Kb: burden factor.
Ktf: overdimensioning factor for DC offset.
Krem: remanence overdimensioning factor.

- **Symmetrical Short-Circuit Current Factor (Kssc)**

It is the ratio between the maximum short circuit current and the rated current.

- **Burden Factor (Kb)**

It is the ratio (Rct+Rburden)/(Rct+Rn), where:

Rn is the rated burden. Rn can be calculated from the CT rated power:

$$Rn = \frac{Pn}{I2n^2}$$

Rct: is the internal secondary resistance of the CT
Rburden: is the burden resistance
I2n: is the rated secondary current

The accuracy limit factor is defined for the rated burden. For a different burden the maximum symmetrical current that assures the fulfillment of the accuracy class will be different than the accuracy limit current (it will be higher than the accuracy limit current if the burden is lower than the rated one and it will be lower if the burden is higher than the rated one). This condition is taken into account by the burden factor.

- **Transient Overdimensioning Factor (Ktf)**

The flux created by a current with DC offset (asymmetrical current) is much higher than the flux generated by a current without any DC component (symmetrical current). As the ALF factor is defined for a symmetrical current, an overdimensioning factor for asymmetrical currents must be considered. This factor will be given by $\frac{\phi_{\text{MAX AC+DC}}}{\phi_{\text{MAX AC}}}$,which represents the ratio between the maximum total flux (sum of DC and AC fluxes) and the maximum AC flux. Ktf is calculated with the following formula:

$$Ktf = \frac{w \cdot T1 \cdot T2}{T1 - T2} \cdot \cos\theta \cdot (e^{\frac{-t}{T1}} - e^{\frac{-t}{T2}}) + \sin\theta \cdot e^{\frac{-t}{T2}} - \sin(wt + \theta) \qquad (3.34.1)$$

where

T1 is the primary time constant.
T2 is the secondary time constant.
t is the saturation free time or time to saturation.
θ is the fault inception angle.

For saturation free times higher than 15 ms, the maximum flux will be obtained with $\theta = 0$, however, for saturation free times lower than 15 ms, the maximum flux will be obtained for other fault inception angles.

For each saturation free time tolerated by the protection function the worst inception angle should be determined.

- **Remanence Overdimensioning Factor (Krem)**

The remanent flux may worsen the CT transient response if it has the same sign of the flux generated by the current magnitude, burden value and DC offset. This is considered by the remanence overdimensioning factor $Krem = \frac{1}{(1 - Kr)}$, where Kr is the remanent factor (maximum remanent flux / saturation flux).

3.34.2.b Class C of IEEE C57.13 Standard

The most common accuracy class in the IEEEC57.13 standard is the C class. The letter C is followed by a number that indicates the secondary voltage rating, which is defined as the CT secondary voltage that the CT will deliver when it is connected to a standard secondary burden at 20 times the rated secondary current, without exceeding a 10% ratio error. The common standard burdens for protection CTs are 1, 2, 4 and 8 ohms, which correspond, at 5 A rated current, to 100, 200, 400 and 800 V secondary rating voltages (for a C100 CT the voltage at the 1 ohm burden will be 20*5*1=100 V).

With the secondary voltage rating (burden voltage - Vb) we can obtain the internal magnetizing voltage by adding the voltage drop in the secondary resistance (Rct):

Emrated=Vb+Rct*20*I2n

The dimensioning of an IEEE CT can be done by calculating Em as:

Emcalc=Ktotal'*I2n*(Rct+Rb),

where Ktotal'=Kssc*Ktf*Krem.

If Emcalc<Emrated= Vb+Rct*20*I2n the CT will be valid

An easier deduction can be made considering that the ALF factor of a C class CT is always 20 (the 10% ratio error cannot be exceeded for a secondary current 20 times the rated current with the rated burden). If Ktotal<ALF the CT will be valid.

3.34.2.c Class X of BS3938 Standard or Class PX of IEC61869-2

Class X CT is defined with:

- Primary and secondary rated currents.
- Transformation ratio.
- Rated knee-point voltage.
- Magnetizing current at rated knee-point voltage.
- Resistance of secondary winding.

The rated knee-point voltage is defined as the minimum voltage, at rated frequency, applied to the CT secondary terminals which increased by a 10% causes an increase in the magnetizing current of 50% (see Figure 3.34.1).

The relationship between the rated knee-point voltage (Vknee) and the magnetizing voltage at the accuracy limit current with rated burden (Emrated) is done by approximation, because the definition of the two voltages has no direct relation (Vknee has to do with the slope of the magnetizing characteristic and Emrated with the current composite error). It is normally considered that Emrated=(1.25 – 1.3)*Vknee.

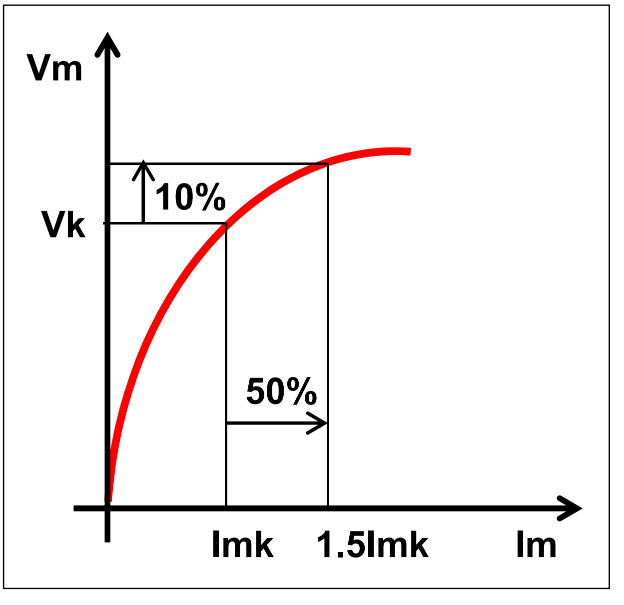


Figure 3.34.1 Knee Point Voltage Definition.

Once Emrated is calculated it can be compared with Emcalc= Ktotal'*I2n*(Rct+Rb). The CT will be valid if Emcalc<Emrated.

where Ktotal'=Kssc*Ktf*Krem

3.34.3 CT Dimensioning for Different Protection Functions

Table 3.34-1 includes general parameters to be considered for the calculation of CT dimensioning factors.

Table 3.34-2 includes the saturation free times (for Ktf calculation) and current values (for Kssc calculation) that must be used for CT dimensioning.

Table 3.34-1: General Parameters

Data	Description	Units
f	Frequency (50 or 60 Hz)	(Hz)
IF	Maximum primary fault current (single phase fault current or three phase fault current, the highest one). It depends on the protection function – see Table 3.34-2	(A)
CT ratio	I1n/I2n	
I1n	Primary nominal current	(A)
I2n	Secondary nominal current	(A)
T1	Primary time constant = L/R (taking into account the total impedance from the source to the fault location).	(s)
T2	Secondary time constant (CT time constant) (Usual value = 3 s)	(s)
Rn	CT nominal resistance	(ohms)
Rct	CT internal resistance For CTs of 5 A nominal current, the Rct is around 0.2 ohms to 0.4 ohms. For the CTs of 1 A nominal current, the Rct is higher (10 ohms for example).	(ohms)
Rb	CT burden resistance = Relay burden + Cable resistance	(ohms)
	Cable resistance = 2·RL (if the maximum primary fault current belongs to a single phase fault). Cable resistance = RL (when the maximum primary fault current belongs to a 3 phase fault). RL = ρ · (L/S) ρ = resistivity (mm^2*Ω/m) S = cable section (m^2) L = cable length (m)	(ohms)
	Relay burden = (0.2 VA) / ($I2n^2$)	(ohms)
t	Required saturation free time (depends of the protection function – see Table 3.34-2)	(s)

Table 3.34-2: Saturation Free Time and Fault Current Values

Protection Function	Fault Scenarios to be considered	t (s) = the time (seconds) from the fault start until the CT becomes saturated.		IF (fault current to calculate Kssc)
		f = 50 Hz	f = 60 Hz	
87	External fault in the busbar (giving maximum fault current)	$3x10^{-3}$ (s)	$2.5x10^{-3}$ (s)	$IF = IF_{max\_external}$ Maximum fault current for external fault
87N	External fault in the busbar (giving maximum fault current)	$4x10^{-3}$ (s)	$3.5x10^{-3}$ (s)	$IF = IF_{max\_external}$ Maximum fault current for external fault
50	Internal fault giving a fault current equal to the pick-up value	It depends on the primary constant, however, it is always lower than $10x10^{-3}$ (s)	It depends on the primary constant, however, it is always lower than $8.3x10^{-3}$ (s)	$IF = IF_{pickup50}$ (instantaneous overcurrent unit pickup in primary value). IFpickup50 ≈ 0.7 · (IF_2) IF_2=the fault current to be detected by 50 overcurrent protection. It is normally the fault current at 50%-80% of the feeder. **Note 1**: The 0.7 factor is introduced to compensate CT errors, relay errors and short circuit calculation errors. **Note 2**: If the current IF_2 is not known, a first approximation could be done taking IF_1 instead of IF_2; Being IF_1= 80% of the fault current at 0% of the feeder (maximum short circuit current) = 80% ($IF_{0\%}$)
	Internal fault at 0% of the line	It depends on the primary constant, however, it is always lower than $7.4x10^{-3}$ (s)	It depends on the primary constant, however, it is always lower than 6 $x10^{-3}$ (s)	$IF = IF_{0\%}$
21	Internal fault at 0% of the line	$8.4x10^{-3}$ (s)	7 $x10^{-3}$ (s)	$IF = IF_{0\%}$
	Internal fault at 100% of the line	$15x10^{-3}$ (s)	$12.5x10^{-3}$ (s)	$IF = IF_{100\%}$
	Internal fault at the limit of zone 1 reach (normally 80% of the line).	$25x10^{-3}$ (s)	$21x10^{-3}$ (s)	$IF = IF_{80\%}$

3.34.3.a Remanence Factor

Remanence factor is not considered for overcurrent and distance protection. For the mentioned functions Krem=1.

For the rest of the functions Kr=75%-->Krem=4

3.34.3.b Ktf Factor

The following tables include different ktf values calculated according to the formula (3.34.1). The saturation free times included in Table 3.34-2 are considered together with the worst inception angles (θ). T2 is considered equal to 3 s.

Function	T1 (s)	K_{tf}
87T	0.01-0.3	0.43

Function	T1 (s)	K_{tf}
87N	0.01-0.3	0.58

Function	T1 (s)	K_{tf_pickup} 60 Hz	K_{tf_pickup} 50 Hz	$K_{tf\_0\%}$ 60 Hz	$K_{tf\_0\%}$ 50 Hz
50	0.01	1	1	1	1
	≤ 0.02	1	1	1	1
	≤ 0.03	1.15	1.15	1	1
	≤ 0.04	1.48	1.48	1	1
	≤ 0.05	1.6	1.6	1	1
	≤ 0.08	1.9	1.9	1	1
	≤ 0.1	2.1	2.1	1	1
	≤ 0.2	2.4	2.4	1	1
	≤ 0.3	2.5	2.5	1	1

Function	T1 (s)	$K_{tf\ zone1}$ 60 Hz	$K_{tf\ zone1}$ 50 Hz	$K_{tf\ 100\%}$ 60 Hz	$K_{tf\ 100\%}$ 50 Hz	$K_{tf\ 0\%}$ 60 Hz	$K_{tf\ 0\%}$ 50 Hz
21	0.01	4.3	3.9	3.8	3.6	2.3	2.3
	≤ 0.02	5.9	5.5	4.6	4.4	2.6	2.5
	≤ 0.03	6.6	6.3	4.9	4.8	2.7	2.6
	≤ 0.04	7.15	6.8	5.1	5	2.7	2.7
	≤ 0.05	7.46	7.2	5.3	5.2	2.7	2.7
	≤ 0.1	8.14	7.9	5.5	5.5	2.8	2.8
	≤ 0.2	8.5	8.4	5.6	5.6	2.8	2.8
	≤ 0.3	8.6	8.5	5.7	5.7	2.8	2.8

NOTE: For overcurrent and distance functions, Ktotal must be calculated for each of the cases considered (fault at 0% and fault with Ifault=Ipick-up for overcurrent; fault at 0%, 80% and 100% of the line for distance). The maximum value of Ktotal must be used to compare against ALF.

Overcurrent

$$Ktotal_{0\%}=Kssc_{0\%}*Kburden*Ktf_{0\%}*Krem$$

$$Ktotal_{pick\text{-}up}=Kssc_{pick\text{-}up}*Kburden*Ktf_{pick\text{-}up}*Krem$$

$$Ktotal=max(Ktotal_{0\%}, Ktotal_{pick\text{-}up})$$

Distance

$$Ktotal_{0\%}=Kssc_{0\%}*Kburden*Ktf_{0\%}*Krem$$

$$Ktotal_{80\%}=Kssc_{80\%}*Kburden*Ktf_{80\%}*Krem$$

$$Ktotal_{100\%}=Kssc_{100\%}*Kburden*Ktf_{100\%}*Krem$$

$$Ktotal=max(Ktotal_{0\%}, Ktotal_{80\%}, Ktotal_{100\%})$$

Chapter 4.

Maintenance and Troubleshooting

4.1 Alarm Codes

4.1.1 Introduction

6IRV models notify the occurrence of alarms by 3 routes:

- Activation of an Alarm Generation Signal and Event.
- Update of the Alarm Status Magnitude.
- Indication on the HMI Stand-by Screen.

Some **6IRV** models are also provided with a fourth route:

- General alarm counter.

4.1.2 Activation of Signal and Alarm Generation Event

The IED has 2 digital signals to indicate critical and non-critical level alarms:

- Non-critical system error: ERR_NONCRIT
- Critical system error: ERR_CRIT

The activation of any of these signals generates its associated event. These signals can be used as inputs to be processed by the user-developed algorithms. Likewise, these signals can be connected to any of the communications protocols for their remote notification.

4.1.3 Update of the Alarm Status Magnitude

The IED has a magnitude whose value is determined by the combination of active alarms in the IED. This magnitude can be used as input to be processed by the user-developed algorithms. Likewise, a user-developed algorithm can connect this magnitude or the outcome of its processing to any of the communications protocols for transmission. Following Table shows the possible causes of alarm coded by alarm magnitude, together with their level of severity.

Table 4.1-1:Alarm Status Magnitude and Severity Level

Alarm	Value	Severity
Error read settings	0x00000001	CRITICAL
Protection operation error	0x00000020	CRITICAL
Error write settings	0x00000040	CRITICAL
Non-critical error in A/D converter	0x00000080	NON-CRITICAL
Critical error in A/D converter	0x00000100	CRITICAL
Loss of content in non-volatile RAM	0x00000200	NON-CRITICAL
Error in internal clock operation	0x00000400	NON-CRITICAL
Error read/write from FLASH	0x00008000	CRITICAL

In the case of more than one alarm at once, the sum of the codes of these alarms is seen in hexadecimal form.

4.1.4 Indication on the HMI Stand-By Screen

The activation of the Critical System Error signal produces the display of the current magnitude of the status of alarms of the IED in hexadecimal format on the stand-by display of the HMI.

4.1.5 General Alarm Counter

The relay is provided with three counters on the HMI to inform on the number of starts, re-starts and Traps:

- **Number of Starts** (NARRANQS) Informs on the number of times the relay has been cold restarted (relay power supply failure).
- **Number of Restarts** (NREARRAQS) Informs on the number of times the relay has been hot restarted (manually through change in configuration or change of any nominal setting or relay reset).
- **Number of Traps** (NTRAPS) Number of exceptions produced in the relay followed by a reset.

Warning: contact the manufacturer if the unit displays any of these alarms codes or Traps counter increment.

4.2 Troubleshooting

4.2.1 Introduction

The purpose of this Chapter is to allow identifying error conditions in the device so that the user can carry out the appropriate corrective action in each case.

4.2.2 Software with Self-Checking

The relay performs continuous monitoring and self-checking its hardware and software. If any problem is detected, the device will show an alarm message in the HMI as it is explained in the Chapter 4.1, Alarm Codes.

The alarms generated by the self-checking module are divided in two levels, critical and non-critical alarms (table located in Chapter 4.1, Alarm Codes). When there is a non-critical alarm, the corresponding alarm message is displayed in the HMI and the device keeps on working due to the fact that the error level detected does not prevent the basic protection functionality, while when there is a critical alarm along with the error message in the HMI the alarm or watchdog contact of the relay changes its position because the protection goes out of service.

4.2.3 Power Up

If the relay does not appear to power up, verify the following points in order to determine if the error is located in the external wiring, in the power supply module or in the display.

Table 4.2-1: Power Up

Test	Check	Actions
1	Measure the auxiliary voltage on terminals of the relay, verifying that the voltage level and polarity is the one defined on the front label. Verify the positive and negative terminal in the external connection drawing.	If the auxiliary voltage is correct, proceed to test 2. If the auxiliary voltage is not the expected one, verify the wiring, fuses and/or minicircuit breakers should be checked.
2	Verify the alarm/watchdog contact of the relay taking into account the external connection drawing of the device	In the device is in service status and the “ready” LED and display are not switched on, the problem is located in the frontal card of the relay or in the internal cables. If the device is in alarm status the problem is located in the power supply module or in the internal cables. In both situations contact your supplier and the Quality Department of ZIV.

4.2.4 In Service / Alarm Contact

Table 4.2-2: In Service / Alarm Contact		
Test	**Check**	**Actions**
1	Access through the MMI or with the communication program (*Zivercomplus*®) to the setting called as "Unit In Service" which is inside General. If it is enabled proceed to test 2.	If the setting is disabled, enable it and verify that the alarm/watchdog contact switched from alarm status to in service status. If it does not change, proceed to test 2.
2	Check if there is any alarm message in the MMI and verify if it is a critical alarm taking into account the table located in the Chapter 4.1, Alarm Codes.	Contact your supplier and the Quality Department of ZIV.

4.2.5 Error Messages during Power Up

If the device, once the power up process has finished, is not showing the default screen (model, date and time) verify the following points.

- **IEC61850 Devices**

Table 4.2-3: Error Messages during Power Up - IEC61850 Devices		
Test	**Check**	**Actions**
1	IEC61850 power up stops showing the following message: ---------------.CID	Protection is operating but communications cannot run because the device has no CID file. Load a correct CID file to the relay.
2	IEC61850 power up stops showing the 3010 error	Protection is operating but communications cannot run because there is a problem while loading the IEC61850 profile. Contact your supplier of the Quality Department of ZIV.
3	IEC61850 power up stops showing the 3011 error	Protection is operating but communications cannot run because there is a problem while loading the CID file. Verify in the logs (web server or FTP) the error reason, modify the CID file and load the corrected file.
4	IEC61850 power up stops showing the 3020 error	Protection is operating but communications cannot run because the FW version of the protection and the IEC61850 FW are not matching. Contact your supplier of the Quality Department of ZIV.
5	IEC61850 power up stops showing the 3030 error	Protection is operating but communications cannot run because there is a mistake in the external control logic configuration of the CID (InRefs, LOGGAPC). Verify in the logs (web server or FTP) the error reason, modify the CID file and load the corrected file.

Table 4.2-3: Error Messages during Power Up - IEC61850 Devices		
Test	**Check**	**Actions**
6	IEC61850 power up stops showing the 3060 error	Protection is operating but communications cannot run because there is a mistake in the GOOSE subscription configuration. Verify in the logs (web server or FTP) the error reason, modify the CID file and load the corrected file.
7	IEC61850 power up stops showing the 3070 error	Protection is operating but communications cannot run because there is an error in the internal file that manages the Ethernet connection. Contact your supplier of the Quality Department of ZIV.
8	IEC61850 power up stops showing the 3080 error	Protection is operating but communications cannot run because there is a problem in the interfaces. Contact your supplier of the Quality Department of ZIV.
9	IEC61850 power up stops showing the 3200 error	Protection is operating but communications cannot run because there is a problem with the interruptions of the DPRAM. Contact your supplier of the Quality Department of ZIV.
	If there is a generic non IEC61850 error message in the HMI, check which kind of error it is according to the table that appears in Chapter 4.1, Alarm Codes.	Contact your supplier of the Quality Department of ZIV.

- **Non IEC61850 Devices**

Table 4.2-4: Error Messages during Power Up – Non IEC61850 Devices		
Test	**Check**	**Actions**
1	If there is an error message in the HMI, check which kind of error it is according to the table that appears in Chapter 4.1, Alarm Codes.	Contact your supplier of the Quality Department of ZIV.

4.2.6 Error Messages when the Relay is in Normal Operation

Table 4.2-5: Error Messages when the Relay is in Normal Operation		
Test	**Check**	**Actions**
1	If there is an error message in the MMI, check which kind of error it is according to the table that appears in Chapter 4.1, Alarm Codes.	Contact your supplier of the Quality Department of ZIV.

4.2.7 Errors while Communicating

Table 4.2-6: Errors while Communicating		
Test	**Check**	**Actions**
1	If a communication error takes place when trying to communicate with *Zivercomplus*® program through the frontal port with the following message: Doesn't communicate. Cannot get identifier.	Verify: - That you are using a crossed cable (5-5, 2-3). - That you are using a USB cable and you have all the drivers installed. - That the communication parameters of the device and the ones set in *Zivercomplus*® fit. Click two times in the screen of *Zivercomplus*® and scan the PC port used for the connection with the relay to obtain automatically the suitable parameters. If even with those parameters the message is still appearing, contact your supplier and the Quality Department of ZIV.
2	If a communication error takes place when trying to communicate with *Zivercomplus*® program through the frontal port with the following message: Cannot locate the identifier corresponding profile: XXXX.	Close *Zivercomplus*® program, update the database and run again *Zivercomplus*® in order to communicate with the relay.
3	If a communication error takes place when trying to communicate with *Zivercomplus*® program through the serial rear ports of the relay.	Verify: - That you are using a crossed cable (5-5, 2-3). - That the communication parameters of the device and the ones set in *Zivercomplus*® fit. - That the protocol of the rear port has been set to PROCOME. Click two times in the screen of *Zivercomplus*® and scan the PC port used for the connection with the relay to obtain automatically the suitable parameters. If even with those parameters the message is still appearing, contact your supplier and the Quality Department of ZIV.
4	If a communication error takes place when trying to communicate with *Zivercomplus*® program through the Ethernet serial rear ports or the LAN ports of the relay.	Verify: - The IP address of the relay is the same one set in *Zivercomplus*®. - That the TCP port set in *Zivercomplus*® is 32001. - That the LAN parameter selected in *Zivercomplus*® is transparent. - That the IP address of the PC belongs to the same family address of the one set in the relay and the network masks are correct. If the error is still appearing, contact your supplier and the Quality Department of ZIV.

Table 4.2-6: Errors while Communicating		
Test	**Check**	**Actions**
5	Errors when communicating in Modbus and DNP3 through the serial remote ports.	Verify: - That you are using a crossed cable. - That the communication parameters of the device and the ones set in Zivercomplus fit. - That the rear port in the relay has been set with the appropriate protocol. - That the control configuration of the relay has the addresses requested by the client. If you cannot communicate, verify the correct behavior of the port trying to communicate in PROCOME with *Zivercomplus*®. If it works, check again the initial points. If it does not work, contact your supplier and the Quality Department of ZIV.
6	Errors when communicating in Modbus and DNP3 through the serial Ethernet ports.	Verify: - The IP address of the relay is the same one set in *Zivercomplus*®. - That the TCP port fits. - The rear port is set with the appropriate protocol. - That the control configuration of the relay has the addresses requested by the client. - That the IP address of the PC/client belongs to the same family address of the one set in the relay and the network masks are correct. If you cannot communicate, verify the correct behavior of the port trying to communicate in PROCOME with *Zivercomplus*®. If it works, check again the initial points. If it does not work, contact your supplier and the Quality Department of ZIV.
7	Errors when communicating in Modbus and DNP3 through the IEC61850 LAN ports.	Verify: - That the model supports DNP3 and MODBUS through the LAN IEC61850 ports as defined in the model selection. - The IP address of the relay is the same one set in the PC/client. - That the TCP port fits. - The rear port is set with the appropriate protocol. - That the control configuration of the relay has the addresses requested by the client. - That the IP address of the PC/client belongs to the same family address of the one set in the relay and the network masks are correct. - That the number of instances of each protocol have not been exceeded. - That there is no IEC61850 error in HMI of the relay (press ▲•). If you cannot communicate, verify the correct behavior of the port trying to communicate in PROCOME with *Zivercomplus*®. If it works, check again the initial points. If it does not work, contact your supplier and the Quality Department of ZIV.

4.2.8 Error in Digital Inputs

Table 4.2-7: Error in Digital Inputs		
Test	**Check**	**Actions**
1	Verify with a multimeter that the DI is energized (positive and negative as external connection wiring diagram) checking the voltage level and polarity taking into account the indications of the front label of the relay.	If the voltage supply of the DI is correct (positive and negative) skip to step 2. If the auxiliary voltage is not the expected one, check the external wiring, fuses and/or mini circuit breakers of the circuit.
2	If you are using a DI that can be configured for coil supervision, check that the corresponding setting has been set to NO.	Access through HMI or *Zivercomplus®* to the coil supervision settings and disable them. If they were enabled go to step 3.
3	Check the activation/deactivation voltage levels as the table that appears in Digital Inputs inside Chapter 2.1, Technical Data.	If the voltage is located inside the activation margin and the DI is not activating, verify that the FW of the relay matches with the model of the front label of the relay. In any case contact your supplier and the Quality Department of ZIV.

4.2.9 Error in Digital Outputs

Table 4.2-8: Error in Digital Outputs		
Test	**Check**	**Actions**
1	If the output contacts are not operating.	Verify the control logic and the signals that activate the outputs. If it is correct, make the necessary actions in order to execute the control logic and give the closing command. Verify if the output is changing the status in the HMI of the relay. If any of the outputs are not operating contact your supplier or the Quality Department of ZIV. If you are seeing the DO changing in the HMI, verify the activation of the output contact a multimeter, taking into account the external connection wiring diagram. If the physical output is not activating, contact your supplier and the Quality Department of ZIV.
2	If the TRIP contacts are not operating when there is a trip condition indicated in the HMI.	Verify that the protection unit is not taking into account the status of the breaker or other kind of factors. If the tripping condition is being complied but the trip contacts are not closed after verifying them with a multimeter and the external connection wiring diagram, contact your supplier and the Quality Department of ZIV.
3	If the CLOSE contacts are not operating when the relay gives a reclosing command.	Repeat the action to generate a new reclosing command, verifying that the command is generated in the events of the relay and the close contact is not closing (with a multimeter and the external connection wiring diagram). If the DO is not activating, contact your supplier and the Quality Department of ZIV.

4.2.10 Error in Input Transducers

Table 4.2-9: Error in Input Transducers

Test	Check	Actions
1	Verify that the input transducer has a suitable input signal taking into account the type of input transducer of the relay (front label of the relay and model selection).	If the input signal is not the expected one, check the external wiring, intermediate devices, etc. If the input signal is the correct one, contact your supplier and the Quality Department of ZIV.

4.2.11 Error in Measurements

- Compare the measurements shown in the HMI of the relay with the magnitudes metered with a multimeter in the terminals of the relay.
- Check that the transformation ratios of the CTs and VTs are the correct ones.
- Check that the terminals wired in the relay are the correct ones (external connection wiring diagram).
- Check the angle shift in order to confirm that the inputs are correctly wired.

If all the verifications are correct (external wiring, polarity and measurements in terminals of the relay), contact your supplier and the Quality Department of ZIV.

4.2.12 Fatal Errors

The device can reset itself in order to escape from transient anomalies, whose cause could be internal or external to the relay and which do not imply a damage of the relay itself. When there is an evidence of a malfunctionality of the device and/or a spontaneous reset, access through the HMI to the FW information screen (ENT / Information / Relay Information / Software/) and check if it is appearing a numerical code inside brackets [xx] in the line which is located between the firmware model and the version and checksum. If so, collect the available information of the relay (events, logs, fault reports, disturbance recorder files, etc.) and contact your supplier and the Quality Department of ZIV.

A. PROCOME 3.0 Protocol

A.1 Control Application Layer

- **Application Functions**

☑ **Initialization of the secondary station**
☑ **Clock synchronization**
☑ **Control functions**
  ☑ Control interrogation
  ☑ Refreshing of digital control signals
  ☑ Write outputs
  ☑ Enabling and disabling of inputs
  ☑ Overflow
  ☑ Force single coil

- **Compatible ASDUs in Secondary-to-Primary Direction**

☑	**<5>**	**Identification**
☑	**<6>**	**Clock synchronization**
☑	**<100>**	**Transmission of metering values and digital control signal changes**
☑	**<101>**	**Transmission of counters**
☑	**<103>**	**Transmission of digital control states**
☑	**<110>**	**Write binary outputs**
☑	**<121>**	**Force single coil**

- **Compatible ASDUs in Primary to Secondary Direction**

☑	**<6>**	**Clock synchronization**
☑	**<100>**	**Control data request (Metering values and control changes INF=200)**
☑	**<100>**	**Control data request (Capture of counters INF=202)**
☑	**<100>**	**Control data request (Request for counters INF=201)**
☑	**<103>**	**Request for digital control states**
☑	**<110>**	**Write binary outputs**
☑	**<112>**	**Enable/disable binary inputs**
☑	**<121>**	**Force single coil**

A.2 Control Data

- **Control Metering (MEA-s)**

Configurable through the ***ZivercomPlus***®: any value measured or calculated by the protection or generated by the programmable logic. It is possible to select between primary and secondary values, taking into account the corresponding transformation ratios.

All the full scale values of the magnitudes are definable, and these magnitudes can be used to create **user values**. Some typical values are:

- Phase and sequence currents and harmonics: **Rated value I_{PHASE} + 20**% sends 4095 counts.
- Ground and synchronization currents: **Rated value I_{GROUND} + 20%** sends 4095 counts.
- Line-to-neutral and sequence voltages and harmonics: **(Rated value V / √3) + 20%** sends 4095 counts.
- Phase-to-phase and polarization voltages: **Rated value V + 20%** sends 4095 counts.
- Powers: 3 x 1.4 x Rated value I_{PHASE} x Rated value / √3 sends 4095 counts.
- Power factor: from **–1** to **1** sends from –4095 to 4095 counts.
- Frequency: from **0 Hz** to **1.2 x Frequency_{RATED}** (50Hz / 60Hz) sends 4095 counts.
- Thermal value: **240%** sends 4095 counts
- Distance to the fault:
  - Percentage value: **±100%** sends ±4095 counts (range from -100% to 100%).
  - Value in kilometers: with the "**length of the line**," it sends ±4095 counts (range from 0 km to the length of the line set in km. It can also send negative values).
  - Value in miles: with the "**length of the line**," it sends ±4095 counts (range from 0 km to the length of the line set in miles. It can also send negative values).

With the ***ZivercomPlus***® program, it is possible to define the full-scale value to be used to transmit this magnitude in counts, the unit that all the protocols use. There are three definable parameters that determine the range of distance covered:

- **Offset value**: the minimum value of the magnitude for which 0 counts are sent.
- **Limit**: the length of the range of the magnitude on which it is interpolated to calculate the number of counts to send. If the offset value is 0, it coincides with the value of the magnitude for which the defined maximum of counts (4095) is sent.
- **Nominal flag**: this flag allows determining whether the limit set is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user in the programmable logic can be configured, while the rest of the existing magnitudes are fixed.

The expression that allows defining this full-scale value is the following:

- When the Nominal flag is enabled,

$$CommunicationsMeasurement = \frac{Measurement - Offset}{Nominal} \times \frac{4095}{Limit}$$

- When the Nominal flag is NOT enabled,

$$CommunicationsMeasurement = (Measurement - Offset) \times \frac{4095}{Limit}$$

- **Counters**

Configurable through the ***ZivercomPlus***®: Counters can be created with any signal configured in the programmable logic or from the protection modules. The default counters are those of the real energies (positive and negative) and the reactive energies (capacitive and inductive).

The metering range of energies in primary values is from 100wh/varh to 99999 MWh/Mvarh. The magnitude transmitted via communications is this same primary value; that is, one (1) count represents 100 wh/varh.

- **Force Single Coil (ISE-s)**

Configurable through the ***ZivercomPlus***®: A command can be made on any input from the protection modules and on any signal configured in the programmable logic.

- **Write Control Outputs (ISS-s)**

Configurable through the ***ZivercomPlus***®: A writing can be made on any input from the protection modules and on any signal configured in the programmable logic.

- **Digital Control Signals (ISC-s)**

Configurable through the ***ZivercomPlus***®: Any input or output logic signal from the protection modules or generated by the programmable logic.

B. DNP V3.00 Device Profiles Document

Dnp3 Basic Profile

(Version 02.44.00 is the last Software Version that supports this Profile)

Basic Profile

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IRV

	☐ ☒

Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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MMI

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QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS

Function Codes

1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
6	Direct Operate-No ACK
7	Immediate Freeze
8	Immediate Freeze no ACK
13	Cold Start
14	Warm Start
20	Enable Unsol. Messages
21	Disable Unsol. Messages
23	Delay Measurement
129	Response
130	Unsolicited Message

7	6	5	4	3	2	1	0
	Index Size			Qualifier Code			

Index Size

0- No Index, Packed
1- 1 byte Index
2- 2 byte Index
3- 4 byte Index
4- 1 byte Object Size
5- 2 byte Object Size
6- 4 byte Object Size

Qualifier Code

0- 8-Bit Start and Stop Indices
1- 16-Bit Start and Stop Indices
2- 32-Bit Start and Stop Indices
3- 8-Bit Absolute address Ident.
4- 16-Bit Absolute address Ident.
5- 32-Bit Absolute address Ident.
6- No Range Field (all)
7- 8-Bit Quantity
8- 16-Bit Quantity
9- 32-Bit Quantity
11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (IRV will parse)		RESPONSE (IRV will respond)		
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**	**Notes**
1	0	Binary Input – All variations	1	6			
1	1	Binary Input			129	1	Assigned to Class 0.
2	0	Binary Input Change – All variations	1	6,7,8			
2	1	Binary Input Change without Time	1	6,7,8	129		B
2	2	Binary Input Change with Time	1	6,7,8	129,130	28	Assigned to Class 1.
2	3	Binary Input Change with Relative Time	1	6,7,8	129		B
10	0	Binary Outputs – All variations	1	6	129		A
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	
20	0	Binary Counter – All variations	1	6	129		A
20	1	32 Bits Binary Counter			129	1	
21	0	Frozen Counter – All variations	1	6	129		A
21	1	32 Bits Frozen Counter			129	1	
22	0	Counter Change Event – All variations	1	6,7,8	129		B
30	0	Analog Input – All variations	1	6			
30	2	16-Bit Analog Input			129	1	Assigned to Class 0.
32	0	Analog Change Event – All variations	1	6,7,8			
32	4	16-Bit Analog Change Event with Time			129,130	28	Assigned to Class 2.
40	0	Analog Output Status – All variations	1	6	129		A
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129		A
50	1	Time and Date	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (IRV will parse)		RESPONSE (IRV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	N/A		B
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

A: Device implementation level does not support this group and variation of object or, for static objects, it has no objects with this group and variation. **OBJECT UNKNOWN** response (IIN2 bit 1 set).

B: No point range was specified, and device has no objects of this type. **NULL response** (no IIN bits set, but no objects of the specified type returned).

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1 and 2) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured "on", then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as** 50 Binary Input Changes **and** 50 Analog Input Changes**. If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- Configuration ➔ Binary Inputs/Outputs **menu: contains the default configuration (as shipped from factory or after a reset by means of F4 key), but customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assigned to Class 1.		
Index	Description	
0	*Configure by ZIVercomPlus*® 2048 points	
1	*Configure by ZIVercomPlus*® 2048 points	
2	*Configure by ZIVercomPlus*® 2048 points	
3	*Configure by ZIVercomPlus*® 2048 points	
4	*Configure by ZIVercomPlus*® 2048 points	
5	*Configure by ZIVercomPlus*® 2048 points	
6	*Configure by ZIVercomPlus*® 2048 points	
7	*Configure by ZIVercomPlus*® 2048 points	
8	*Configure by ZIVercomPlus*® 2048 points	
9	*Configure by ZIVercomPlus*® 2048 points	
10	*Configure by ZIVercomPlus*® 2048 points	
11	*Configure by ZIVercomPlus*® 2048 points	
12	*Configure by ZIVercomPlus*® 2048 points	
13	*Configure by ZIVercomPlus*® 2048 points	
14	*Configure by ZIVercomPlus*® 2048 points	
15	*Configure by ZIVercomPlus*® 2048 points	
16	*Configure by ZIVercomPlus*® 2048 points	
17	*Configure by ZIVercomPlus*® 2048 points	
...	*Configure by ZIVercomPlus*® 2048 points	
253	*Configure by ZIVercomPlus*® 2048 points	
254	*Configure by ZIVercomPlus*® 2048 points	
255	*Configure by ZIVercomPlus*® 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
0	***Configure by ZIVercomPlus⑧ 256 points***	
1	***Configure by ZIVercomPlus⑧ 256 points***	
2	***Configure by ZIVercomPlus⑧ 256 points***	
3	***Configure by ZIVercomPlus⑧ 256 points***	
4	***Configure by ZIVercomPlus⑧ 256 points***	
5	***Configure by ZIVercomPlus⑧ 256 points***	
6	***Configure by ZIVercomPlus⑧ 256 points***	
7	***Configure by ZIVercomPlus⑧ 256 points***	
8	***Configure by ZIVercomPlus⑧ 256 points***	
9	***Configure by ZIVercomPlus⑧ 256 points***	
10	***Configure by ZIVercomPlus⑧ 256 points***	
11	***Configure by ZIVercomPlus⑧ 256 points***	
12	***Configure by ZIVercomPlus⑧ 256 points***	
13	***Configure by ZIVercomPlus⑧ 256 points***	
14	***Configure by ZIVercomPlus⑧ 256 points***	
15	***Configure by ZIVercomPlus⑧ 256 points***	
16	***Configure by ZIVercomPlus⑧ 256 points***	
17	***Configure by ZIVercomPlus⑧ 256 points***	
...	***Configure by ZIVercomPlus⑧ 256 points***	
253	***Configure by ZIVercomPlus⑧ 256 points***	
254	***Configure by ZIVercomPlus⑧ 256 points***	
255	***Configure by ZIVercomPlus⑧ 256 points***	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assigned to Class 2.		
Index	Description	Deadband
0	*Configure by ZIVercomPlus*® 512 points	Deadband_1.
1	*Configure by ZIVercomPlus*® 512 points	Deadband_2.
2	*Configure by ZIVercomPlus*® 512 points	Deadband_3.
3	*Configure by ZIVercomPlus*® 512 points	Deadband_4.
4	*Configure by ZIVercomPlus*® 512 points	Deadband_5.
5	*Configure by ZIVercomPlus*® 512 points	Deadband_6.
6	*Configure by ZIVercomPlus*® 512 points	Deadband_7.
7	*Configure by ZIVercomPlus*® 512 points	Deadband_8.
8	*Configure by ZIVercomPlus*® 512 points	Deadband_9.
9	*Configure by ZIVercomPlus*® 512 points	Deadband_10.
10	*Configure by ZIVercomPlus*® 512 points	Deadband_11.
11	*Configure by ZIVercomPlus*® 512 points	Deadband_12.
12	*Configure by ZIVercomPlus*® 512 points	Deadband_13.
13	*Configure by ZIVercomPlus*® 512 points	Deadband_14.
14	*Configure by ZIVercomPlus*® 512 points	Deadband_15.
15	*Configure by ZIVercomPlus*® 512 points	Deadband_16.

Additional assign with *ZIVercomPlus*⑧:

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0.	
Index	**Description**
16	***Configure by ZIVercomPlus⑧ 512 points***
17	***Configure by ZIVercomPlus⑧ 512 points***
18	***Configure by ZIVercomPlus⑧ 512 points***
19	***Configure by ZIVercomPlus⑧ 512 points***
20	***Configure by ZIVercomPlus⑧ 512 points***
21	***Configure by ZIVercomPlus⑧ 512 points***
22	***Configure by ZIVercomPlus⑧ 512 points***
23	***Configure by ZIVercomPlus⑧ 512 points***
24	***Configure by ZIVercomPlus⑧ 512 points***
25	***Configure by ZIVercomPlus⑧ 512 points***
26	***Configure by ZIVercomPlus⑧ 512 points***
27	***Configure by ZIVercomPlus⑧ 512 points***
....	***Configure by ZIVercomPlus⑧ 512 points***
254	***Configure by ZIVercomPlus⑧ 512 points***
255	***Configure by ZIVercomPlus⑧ 512 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	**Full Scale Range**		
	Engineering units	**Counts**	
Currents (Phases, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**Deadband**
Currents (Ground, polarizing)	0 to 1,2 x In_{GROUND} A	0 to 32767	**Deadband**
Currents (Ground sensitive, isolated neutral)	0 to 1,2 A	0 to 32767	**Deadband**
Voltages (Phase to ground, sequences, harmonics)	0 to 1,2 x Vn/√3 V	0 to 32767	**Deadband**
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	**Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	**Deadband**
Power factor	-1 to 1	-32768 to 32767	**Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**Deadband**
Thermal value	0 to 200%	0 to 32767	**Deadband**
Distance to Fault - **Percentage of line length:** 100% sends 32767 counts (range from -100% to 100%) - **Distance in kilometers:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in km) - **Distance in miles:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in miles)		-32768 to 32767	**Deadband**

With ***ZIVercomPlus®*** program it's possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*, which is the unit used by the protocol. There are three parameters to determine the distance range covered:

- **Offset:** minimum value of each magnitude to transmit 0 counts.
- **Limit:** it's the length of the magnitude range used to calculate the number of counts to transmit. If **offset** is 0, it's the same as the value of the magnitude for which the maximum number of counts defined by the protocol is sent (32767 counts).
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureComm = \frac{Measure - Offset}{RatedValue} \times \frac{32767}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureComm = (Measure - Offset) \times \frac{32767}{Limit}$$

Deadbands

- Deadbands are used for configuring *Analog Input Change* objects (Object 32).
- A Deadband is defined as a percentage over the **Full Scale Range (FSR)**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface), between 0.00% and 100.00%, in steps of 0.01%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Analog Input.

Energy counters

The range for the energy counters in primary values is from 100wh/varh to 99999Mwh/Mvarh, and these are the values transmitted by protocol.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings						
DNP Protocol Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
DNP Port 1 Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Baud rate	**Integer**	**300**	**38400**	**38400**	**300 600 1200 2400 4800 9600 19200 38400**	**baud**
Stop Bits	**Integer**	**1**	**2**	**1**	**1**	
Parity	**Integer**	**None Odd Even**	**None Odd Even**	**None**	**None Odd Even**	
Rx Time btw. Char	**Float**	**1**	**60000**	**0.5**	**40**	**msec.**
Comms Fail Ind. Time	**Float**	**0**	**600**	**0.1**	**60**	**s**

Advaced settings						
Flow control						
CTS Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Sensitive	Bool	No Yes	No Yes	No	No Yes	
DTR Control	Integer	Inactive Active Rec. Req.	Inactive Active Rec. Req.	Inactive	Inactive Active Rec. Req.	
RTS Control	Integer	Inactive Active Rec. Req. Sen. Req.	Inactive Active Rec. Req. Sen. Req.	Inactive	Inactive Active Rec. Req. Sen. Req.	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO DCD	NO ECHO DCD	NO	NO ECHO DCD	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

DNP Port 2 Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Protocol Select	Uinteger	Procome Dnp3 Modbus	Procome Dnp3 Modbus	Procome	Procome Dnp3 Modbus	
Baud rate	Integer	300	38400	38400	300 600 1200 2400 4800 9600 19200 38400	baud
Stop Bits	Integer	1	2	1	1	
Parity	Integer	None Odd Even	None Odd Even	None	None Odd Even	
Rx Time btw. Char	Float	1	60000	0.5	40	msec.
Comms Fail Ind. Time	Float	0	600	0.1	60	s

Advaced settings						
Operating Mode	**Integer**	**RS-232 RS-485**	**RS-232 RS-485**	**RS-232**	**RS-232 RS-485**	
Times						
Tx Time Factor	**Float**	**0**	**100**	**1**	**0.5**	
Tx Timeout Const	**Uinteger**	**0**	**60000**	**0**	**1**	
Wait N Bytes 485	**Integer**	**0**	**4**	**0**	**1**	
Message modification						
Number of Zeros	**Integer**	**0**	**255**	**0**	**1**	
collision						
Collision Type	**Integer**	**NO ECHO**	**NO ECHO**	**NO**	**NO ECHO**	
Max Retries	**Integer**	**0**	**3**	**0**	**1**	
Min Retry Time	**Uinteger**	**0**	**60000**	**0**	**1**	**msec.**
Max Retry Time	**Uinteger**	**0**	**60000**	**0**	**1**	**msec.**
Analog Inputs (Deadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband AI#0	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#1	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#2	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#3	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#4	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#5	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#6	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#7	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#8	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#9	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#10	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#11	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#12	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#13	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#14	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#15	Float	0 %	100 %	100 %	0.01 %	

✓ **All settings remain unchanged after a power loss.**

DNP Protocol Configuration

- **Relay Number (RTU Address):**
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- **T Confirm Timeout (N7 Confirm Timeout) :**
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- **Max Retries (N7 Retries) :**
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- **Enable Unsolicited (Enable Unsolicited Reporting) :**
  Enables or disables Unsolicited reporting.
- **Enable Unsol. after Restart :**
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.

- **Unsolic. Master No. (MTU Address) :**
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- **Unsol. Grouping Time (Unsolicited Delay Reporting) :**
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- **Synchronization Interval**
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- **DNP 3.0 Rev.**
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)

DNP Port 1 and Port 2 Configuration

- **Number of Zeros** **(Advice_Time) :**
  Number of zeros before the message.
- **Max Retries** **(N1 Retries) :**
  Number of retries of the Physical Layer after collision detection.
- **Min Retry Time** **(Fixed_delay) :**
  Minimum time to retry of the Physical Layer after collision detection.
- **Max Retry Time :**
  Maximum time to retry of the Physical Layer after collision detection.
- **Collision Type :**

  Port 1:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link).

  Port 2:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link.

  DCD (Data Carrier Detect) based on detecting out-of-band carrier.

  If the device prepares to transmit and finds the link busy, it waits until is no longer busy, and then waits a backoff_time as follows:

  backoff_time = Min Retry Time + random(Max Retry Time - Max Retry Time)

  and transmit. If the device has a collision in transmission the device tries again,up to a configurable number of retries (Max Retries) if has news collision.

- **Wait N Bytes 485:**

Number of wait bytes between Reception and transmission Use Port 2 Operate Mode RS-485.

Dnp3 Basic Extended Profile

(Version 02.45.00 is the first Software Version that supports this Profile)

Basic Extended Profile

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IRV

	☐ ☒

Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS

Function Codes

1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
9	Direct Operate-No ACK
10	Immediate Freeze
11	Immediate Freeze no ACK
13	Cold Start
14	Warm Start
20	Enable Unsol. Messages
21	Disable Unsol. Messages
23	Delay Measurement
129	Response
130	Unsolicited Message

7	6	5	4	3	2	1	0
	Index Size			Qualifier Code			

Index Size

0- No Index, Packed
1- 1 byte Index
2- 2 byte Index
3- 4 byte Index
4- 1 byte Object Size
5- 2 byte Object Size
6- 4 byte Object Size

Qualifier Code

0- 8-Bit Start and Stop Indices
1- 16-Bit Start and Stop Indices
2- 32-Bit Start and Stop Indices
3- 8-Bit Absolute address Ident.
4- 16-Bit Absolute address Ident.
5- 32-Bit Absolute address Ident.
6- No Range Field (all)
7- 8-Bit Quantity
8- 16-Bit Quantity
9- 32-Bit Quantity
11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (IRV will parse)		RESPONSE (IRV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	**1**	6			
1	1	Binary Input			129	1	Assigned to Class 0.
2	0	Binary Input Change – All variations	1	6,7,8			
2	1	Binary Input Change without Time	1	6,7,8	129		B
2	2	Binary Input Change with Time	1	6,7,8	129,130	28	Assigned to Class 1.
2	3	Binary Input Change with Relative Time	1	6,7,8	129		B
10	0	Binary Outputs – All variations	1	6	129		A
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	
20	0	Binary Counter – All variations	1	6	129		~~A~~
20	1	32 Bits Binary Counter			129	1	
21	0	Frozen Counter – All variations	1	6	129		~~A~~
21	1	32 Bits Frozen Counter			129	1	
22	0	Counter Change Event – All variations	1	6,7,8	129		B
30	0	Analog Input – All variations	1	6			
30	2	16-Bit Analog Input			129	1	Assigned to Class 0.
32	0	Analog Change Event – All variations	1	6,7,8			
32	4	16-Bit Analog Change Event with Time			129,130	28	Assigned to Class 2.
40	0	Analog Output Status – All variations	1	6	129		A
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129		A
50	1	Time and Date	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (IRV will parse)		RESPONSE (IRV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	N/A		B
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

A: Device implementation level does not support this group and variation of object or, for static objects, it has no objects with this group and variation. **OBJECT UNKNOWN** response (IIN2 bit 1 set).

B: No point range was specified, and device has no objects of this type. **NULL response** (no IIN bits set, but no objects of the specified type returned).

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1 and 2) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured “on”, then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as** 50 Binary Input Changes **and** 50 Analog Input Changes**. If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- Configuration ➔ Binary Inputs/Outputs **menu: contains the default configuration (as shipped from factory or after a reset by means of F4 key), but customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assigned to Class 1.		
Index	Description	
0	*Configure by ZIVercomPlus*® 2048 points	
1	*Configure by ZIVercomPlus*® 2048 points	
2	*Configure by ZIVercomPlus*® 2048 points	
3	*Configure by ZIVercomPlus*® 2048 points	
4	*Configure by ZIVercomPlus*® 2048 points	
5	*Configure by ZIVercomPlus*® 2048 points	
6	*Configure by ZIVercomPlus*® 2048 points	
7	*Configure by ZIVercomPlus*® 2048 points	
8	*Configure by ZIVercomPlus*® 2048 points	
9	*Configure by ZIVercomPlus*® 2048 points	
10	*Configure by ZIVercomPlus*® 2048 points	
11	*Configure by ZIVercomPlus*® 2048 points	
12	*Configure by ZIVercomPlus*® 2048 points	
13	*Configure by ZIVercomPlus*® 2048 points	
14	*Configure by ZIVercomPlus*® 2048 points	
15	*Configure by ZIVercomPlus*® 2048 points	
16	*Configure by ZIVercomPlus*® 2048 points	
17	*Configure by ZIVercomPlus*® 2048 points	
...	*Configure by ZIVercomPlus*® 2048 points	
253	*Configure by ZIVercomPlus*® 2048 points	
254	*Configure by ZIVercomPlus*® 2048 points	
255	*Configure by ZIVercomPlus*® 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
0	***Configure by ZIVercomPlus® 256 points***	
1	***Configure by ZIVercomPlus® 256 points***	
2	***Configure by ZIVercomPlus® 256 points***	
3	***Configure by ZIVercomPlus® 256 points***	
4	***Configure by ZIVercomPlus® 256 points***	
5	***Configure by ZIVercomPlus® 256 points***	
6	***Configure by ZIVercomPlus® 256 points***	
7	***Configure by ZIVercomPlus® 256 points***	
8	***Configure by ZIVercomPlus® 256 points***	
9	***Configure by ZIVercomPlus® 256 points***	
10	***Configure by ZIVercomPlus® 256 points***	
11	***Configure by ZIVercomPlus® 256 points***	
12	***Configure by ZIVercomPlus® 256 points***	
13	***Configure by ZIVercomPlus® 256 points***	
14	***Configure by ZIVercomPlus® 256 points***	
15	***Configure by ZIVercomPlus® 256 points***	
16	***Configure by ZIVercomPlus® 256 points***	
17	***Configure by ZIVercomPlus® 256 points***	
...	***Configure by ZIVercomPlus® 256 points***	
253	***Configure by ZIVercomPlus® 256 points***	
254	***Configure by ZIVercomPlus® 256 points***	
255	***Configure by ZIVercomPlus® 256 points***	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assigned to Class 2.		
Index	Description	Deadband
0	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_1.
1	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_2.
2	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_3.
3	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_4.
4	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_5.
5	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_6.
6	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_7.
7	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_8.
8	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_9.
9	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_10.
10	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_11.
11	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_12.
12	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_13.
13	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_14.
14	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_15.
15	*Configure by ZIVercomPlus®* 512 points	◊ Deadband_16.

Additional assign with ***ZIVercomPlus***⑧:

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0.	
Index	**Description**
16	***Configure by ZIVercomPlus⑧ 512 points***
17	***Configure by ZIVercomPlus⑧ 512 points***
18	***Configure by ZIVercomPlus⑧ 512 points***
19	***Configure by ZIVercomPlus⑧ 512 points***
20	***Configure by ZIVercomPlus⑧ 512 points***
21	***Configure by ZIVercomPlus⑧ 512 points***
22	***Configure by ZIVercomPlus⑧ 512 points***
23	***Configure by ZIVercomPlus⑧ 512 points***
24	***Configure by ZIVercomPlus⑧ 512 points***
25	***Configure by ZIVercomPlus⑧ 512 points***
26	***Configure by ZIVercomPlus⑧ 512 points***
27	***Configure by ZIVercomPlus⑧ 512 points***
....	***Configure by ZIVercomPlus⑧ 512 points***
254	***Configure by ZIVercomPlus⑧ 512 points***
255	***Configure by ZIVercomPlus⑧ 512 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	**Full Scale Range**		
	Engineering units	**Counts**	
Currents (Phases, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**() Deadband**
Currents (Ground, polarizing)	0 to 1,2 x In_{GROUND} A	0 to 32767	**() Deadband**
Currents (Ground sensitive, isolated neutral)	0 to 1,2 A	0 to 32767	**() Deadband**
Voltages (Phase to ground, sequences, harmonics)	0 to 1,2 x $Vn/\sqrt{3}$ V	0 to 32767	**() Deadband**
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	**() Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x $Vn/\sqrt{3}$ W	-32768 to 32767	**() Deadband**
Power factor	-1 to 1	-32768 to 32767	**() Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**() Deadband**
Thermal value	0 to 200%	0 to 32767	**() Deadband**
Distance to Fault - **Percentage of line length:** 100% sends 32767 counts (range from -100% to 100%) - **Distance in kilometers:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in km) - **Distance in miles:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in miles)		-32768 to 32767	**() Deadband**

With ***ZIVercomPlus®*** program it's possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*, which is the unit used by the protocol. There are three parameters to determine the distance range covered:

- **Offset:** minimum value of each magnitude to transmit 0 counts.
- **Limit:** it's the length of the magnitude range used to calculate the number of counts to transmit. If **offset** is 0, it's the same as the value of the magnitude for which the maximum number of counts defined by the protocol is sent (32767 counts).
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureComm = \frac{Measure - Offset}{RatedValue} \times \frac{32767}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureComm = (Measure - Offset) \times \frac{32767}{Limit}$$

Deadbands

- Deadbands are used for configuring *Analog Input Change* objects (Object 32).
- A Deadband is defined as a percentage over the **Full Scale Range (FSR)**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface), between 0.00% and 100.00%, in steps of 0.01%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Analog Input.

Energy counters

The range for the energy counters in primary values is from 100wh/varh to 99999Mwh/Mvarh, and these are the values transmitted by protocol.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings						
DNP Protocol Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
DNP Port 1 Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Baud rate	**Integer**	**300**	**38400**	**38400**	**300 600 1200 2400 4800 9600 19200 38400**	**baud**
Stop Bits	**Integer**	**1**	**2**	**1**	**1**	
Parity	**Integer**	**None Odd Even**	**None Odd Even**	**None**	**None Odd Even**	
Rx Time btw. Char	**Float**	**1**	**60000**	**0.5**	**40**	**msec.**
Comms Fail Ind. Time	**Float**	**0**	**600**	**0.1**	**60**	**s**

Advaced settings						
Flow control						
CTS Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Sensitive	Bool	No Yes	No Yes	No	No Yes	
DTR Control	Integer	Inactive Active Rec. Req.	Inactive Active Rec. Req.	Inactive	Inactive Active Rec. Req.	
RTS Control	Integer	Inactive Active Rec. Req. Sen. Req.	Inactive Active Rec. Req. Sen. Req.	Inactive	Inactive Active Rec. Req. Sen. Req.	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO DCD	NO ECHO DCD	NO	NO ECHO DCD	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

DNP Port 2 Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Protocol Select	Uinteger	Procome Dnp3 Modbus	Procome Dnp3 Modbus	Procome	Procome Dnp3 Modbus	
Baud rate	Integer	300	38400	38400	300 600 1200 2400 4800 9600 19200 38400	baud
Stop Bits	Integer	1	2	1	1	
Parity	Integer	None Odd Even	None Odd Even	None	None Odd Even	
Rx Time btw. Char	Float	1	60000	0.5	40	msec.
Comms Fail Ind. Time	Float	0	600	0.1	60	s

Advaced settings						
Operating Mode	Integer	RS-232 RS-485	RS-232 RS-485	RS-232	RS-232 RS-485	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Wait N Bytes 485	Integer	0	4	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO	NO ECHO	NO	NO ECHO	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.
Analog Inputs (Deadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband AI#0	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#1	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#2	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#3	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#4	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#5	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#6	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#7	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#8	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#9	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#10	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#11	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#12	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#13	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#14	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#15	Float	0 %	100 %	100 %	0.01 %	

✓ **All settings remain unchanged after a power loss.**

DNP Protocol Configuration

- Relay Number (**RTU Address**):
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- T Confirm Timeout (**N7 Confirm Timeout)** :
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- Max Retries (**N7 Retries)** :
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- Enable Unsolicited (**Enable Unsolicited Reporting)** :
  Enables or disables Unsolicited reporting.
- Enable Unsol. after Restart :
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.

- Unsolic. Master No. (**MTU Address)** :
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- Unsol. Grouping Time (**Unsolicited Delay Reporting)** :
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- Synchronization Interval
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- DNP 3.0 Rev.
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)

DNP Port 1 and Port 2 Configuration

- **Number of Zeros (Advice_Time) :**
  Number of zeros before the message.
- **Max Retries (N1 Retries) :**
  Number of retries of the Physical Layer after collision detection.
- **Min Retry Time (Fixed_delay) :**
  Minimum time to retry of the Physical Layer after collision detection.
- **Max Retry Time :**
  Maximum time to retry of the Physical Layer after collision detection.
- **Collision Type :**

  Port 1:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link).

  Port 2:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link.

  DCD (Data Carrier Detect) based on detecting out-of-band carrier.

  If the device prepares to transmit and finds the link busy, it waits until is no longer busy, and then waits a backoff_time as follows:

  backoff_time = Min Retry Time + random(Max Retry Time - Max Retry Time)

  and transmit. If the device has a collision in transmission the device tries again,up to a configurable number of retries (Max Retries) if has news collision.

- **Wait N Bytes 485:**
  Number of wait bytes between Reception and transmission Use Port 2 Operate Mode RS-485.

Dnp3 Profile II

(Version 02.46.00 is the first Software Version that supports this Profile)

Profile II

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IRV

	☐ ☒

Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS

Function Codes

Code	Function
1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
6	Direct Operate-No ACK
7	Immediate Freeze
8	Immediate Freeze no ACK
13	Cold Start
14	Warm Start
20	Enable Unsol. Messages
21	Disable Unsol. Messages
23	Delay Measurement
129	Response
130	Unsolicited Message

7	6	5	4	3	2	1	0
	Index Size			Qualifier Code			

Index Size

0- No Index, Packed
1- 1 byte Index
2- 2 byte Index
3- 4 byte Index
4- 1 byte Object Size
5- 2 byte Object Size
6- 4 byte Object Size

Qualifier Code

0- 8-Bit Start and Stop Indices
1- 16-Bit Start and Stop Indices
2- 32-Bit Start and Stop Indices
3- 8-Bit Absolute address Ident.
4- 16-Bit Absolute address Ident.
5- 32-Bit Absolute address Ident.
6- No Range Field (all)
7- 8-Bit Quantity
8- 16-Bit Quantity
9- 32-Bit Quantity
11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (IRV parse)		RESPONSE (IRV respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
1	1	Binary Input	1	0,1,6,7,8	129	0,1	
2	0	Binary Input with Status	1	0,1,6,7,8	129	0,1	
2	0	Binary Input Change – All variations	1	6,7,8			
2	2	Binary Input Change with Time	1	6,7,8	129,130	17,,28	Assign to Event Class
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	Echo of request
20	0	Binary Counter – All variations	1	0,1,6,7,8			Assigned to Class 0.
20	1	32 Bits Binary Counter			129	0,1	
21	0	Frozen Counter – All variations	1	0,1,6,7,8			
21	1	32 Bits Frozen Counter			129	0,1	
22	0	Counter Change Event – All variations	1	6,7,8			
22	5	32 Bits Counter Change Event With Time			129,130	17,,28	Assign to Event Class
30	0	Analog Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	1	
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	1	
32	0	Analog Change Event – All variations	1	6,7,8			
32	3	32-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
32	4	16-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
50	1	Time and Date	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (IRV parse)		RESPONSE (IRV respond)		
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**	**Notes**
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	129,130	28	D
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface ***ZIVercomPlus***). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1, 2 and 3) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured "on", then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as 128** Binary Input Changes**,** 64 Analog Input Changes and 64 Counter Input Change. **If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- **Customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assign to Class.		
Index	**Description**	
0	***Configure by ZIVercomPlus® 2048 points***	
1	***Configure by ZIVercomPlus® 2048 points***	
2	***Configure by ZIVercomPlus® 2048 points***	
3	***Configure by ZIVercomPlus® 2048 points***	
4	***Configure by ZIVercomPlus® 2048 points***	
5	***Configure by ZIVercomPlus® 2048 points***	
6	***Configure by ZIVercomPlus® 2048 points***	
7	***Configure by ZIVercomPlus® 2048 points***	
8	***Configure by ZIVercomPlus® 2048 points***	
9	***Configure by ZIVercomPlus® 2048 points***	
10	***Configure by ZIVercomPlus® 2048 points***	
11	***Configure by ZIVercomPlus® 2048 points***	
12	***Configure by ZIVercomPlus® 2048 points***	
13	***Configure by ZIVercomPlus® 2048 points***	
14	***Configure by ZIVercomPlus® 2048 points***	
15	***Configure by ZIVercomPlus® 2048 points***	
16	***Configure by ZIVercomPlus® 2048 points***	
17	***Configure by ZIVercomPlus® 2048 points***	
...	***Configure by ZIVercomPlus® 2048 points***	
253	***Configure by ZIVercomPlus® 2048 points***	
254	***Configure by ZIVercomPlus® 2048 points***	
255	***Configure by ZIVercomPlus® 2048 points***	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
0	***Configure by ZIVercomPlus® 256 points***	
1	***Configure by ZIVercomPlus® 256 points***	
2	***Configure by ZIVercomPlus® 256 points***	
3	***Configure by ZIVercomPlus® 256 points***	
4	***Configure by ZIVercomPlus® 256 points***	
5	***Configure by ZIVercomPlus® 256 points***	
6	***Configure by ZIVercomPlus® 256 points***	
7	***Configure by ZIVercomPlus® 256 points***	
8	***Configure by ZIVercomPlus® 256 points***	
9	***Configure by ZIVercomPlus® 256 points***	
10	***Configure by ZIVercomPlus® 256 points***	
11	***Configure by ZIVercomPlus® 256 points***	
12	***Configure by ZIVercomPlus® 256 points***	
13	***Configure by ZIVercomPlus® 256 points***	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	Description	
14	*Configure by ZIVercomPlus*⑧ 256 points	
15	*Configure by ZIVercomPlus*⑧ 256 points	
16	*Configure by ZIVercomPlus*⑧ 256 points	
17	*Configure by ZIVercomPlus*⑧ 256 points	
...	*Configure by ZIVercomPlus*⑧ 256 points	
253	*Configure by ZIVercomPlus*⑧ 256 points	
254	*Configure by ZIVercomPlus*⑧ 256 points	
255	*Configure by ZIVercomPlus*⑧ 256 points	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assign to Class		
Index	Description	Deadband
0	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_1.
1	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_2.
2	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_3.
3	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_4.
4	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_5.
5	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_6.
6	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_7.
7	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_8.
8	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_9.
9	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_10.
10	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_11.
11	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_12.
12	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_13.
13	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_14.
14	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_15.
15	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_16.

Additional assign with *ZIVercomPlus*⑧:

Index	Description
16	***Configure by ZIVercomPlus⑧ 256 points***
17	***Configure by ZIVercomPlus⑧ 256 points***
18	***Configure by ZIVercomPlus⑧ 256 points***
19	***Configure by ZIVercomPlus⑧ 256 points***
20	***Configure by ZIVercomPlus⑧ 256 points***
21	***Configure by ZIVercomPlus⑧ 256 points***
22	***Configure by ZIVercomPlus⑧ 256 points***
23	***Configure by ZIVercomPlus⑧ 256 points***
24	***Configure by ZIVercomPlus⑧ 256 points***
25	***Configure by ZIVercomPlus⑧ 256 points***
26	***Configure by ZIVercomPlus⑧ 256 points***
27	***Configure by ZIVercomPlus⑧ 256 points***
....	***Configure by ZIVercomPlus⑧ 256 points***
62	***Configure by ZIVercomPlus⑧ 256 points***
63	***Configure by ZIVercomPlus⑧ 256 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	Full Scale Range		
	Engineering units	Counts	
Currents (Phases, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**() Deadband**
Currents (Ground, polarizing)	0 to 1,2 x In_{GROUND} A	0 to 32767	**() Deadband**
Currents (Ground sensitive, isolated neutral)	0 to 1,2 A	0 to 32767	**() Deadband**
Voltages (Phase to ground, sequences, harmonics)	0 to 1,2 x Vn/√3 V	0 to 32767	**() Deadband**
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	**() Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	**() Deadband**
Power factor	-1 to 1	-32768 to 32767	**() Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**() Deadband**
Thermal value	0 to 200%	0 to 32767	**() Deadband**
Distance to Fault - **Percentage of line length:** 100% sends 32767 counts (range from -100% to 100%) - **Distance in kilometers:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in km) - **Distance in miles:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in miles)		-32768 to 32767	**() Deadband**

Communication Measure in Counts

With ***ZIVercomPlus*** program is possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de Magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Max Communication:** it's a constant that depend of the Number Bits of Analog Input.
  Max Communication=2(Number Bits Analog Input - 1)**
  For 16-Bit Analog Input (Obj 30 Var. 2) 2**(15) = 32.767 counts
  For 32-Bit Analog Input (Obj 30 Var. 1) 2**(31) = 2.147.483.647 counts
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** This *flag* defines if the **limit** is proportional to the **rated value** of the magnitude.
- **TR:** Secondary to Primary Transformation Ratio.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times \frac{MaxComunication}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times \frac{MaxComunication}{Limit}$$

Communication Measure in Engineering Units

With ***ZIVercomPlus*** program **also** it's possible to transmit each magnitude in Engineering Units. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the **rated value** of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.
- **TR:** Secondary to Primary Transformation Ratio.
- **Scaling Factor:** Multiply Factor of magnitude.

Mathematical expression to obtain **Measure in Engineering Units** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times ScalingFactor$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times ScalingFactor$$

DeadBands

- Deadband is an area of a magnitude range or band where no generate magnitude change (the magnitude is dead). Meaning that no generation of Analogical Change Events if difference with value of generation of previous change is not equal or greater that DeadBand calculated. There is an independent setting for each 16 Measures with change.
- A Deadband is calculated as a percentage defined in DeadBand Setting over value of **parameter Limit**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 0.0000% and 100.00%, in steps of 0.0001%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Magnitude with change.

BINARY COUNTER (OBJECT 20) -> Assigned to Class 0. FROZEN COUNTER (OBJECT 21) 32 BIT COUNTER CHANGE EVENT (OBJECT 22) -> Assign to Class		
Index	Description	Deadband
0	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_1.
1	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_2.
2	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_3.
3	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_4.
4	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_5.
5	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_6
6	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_7.
7	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_8.
8	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_9.
9	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_10.
10	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_11.
11	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_12.
12	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_13.
13	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_14.
14	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_15.
15	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_16.
16	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_17.
17	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_18.
18	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_19.
19	*Configure by ZIVercomPlus®* 256 points	CounterDeadBand_20.

CounterDeadBands

- CounterDeadband is an area of a counter magnitude range or band, where no generate counter magnitude change (the communication counter magnitude is dead).Meaning that no generation of Counter Change Events if difference with value of generation of previous change is not equal or greater that CounterDeadBand setting. There is an independent setting for each Counter.

- The CounterDeadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 1 and 32767, in steps of 1, default value is 1.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings						
DNP Protocol Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
Binary Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 1	None Class 1 Class 2 Class 3	
Analog Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 2	None Class 1 Class 2 Class 3	
Counter Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 3	None Class 1 Class 2 Class 3	
Binary Status Change	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	
32 Bits Analog Input	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	
Analog Inputs (Deadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband AI#0	Float	0 %	100 %	100 %	0.0001 %	
Deadband AI#1	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#2	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#3	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#4	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#5	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#6	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#7	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#8	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#9	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#10	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#11	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#12	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#13	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#14	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#15	Float	0 %	100 %	100 %	0. 0001 %	

Counter Inputs (CounterDeadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband Cont.I#0	Integer	1	32767	1	1	
Deadband Cont.I#1	Integer	1	32767	1	1	
Deadband Cont.I#2	Integer	1	32767	1	1	
Deadband Cont.I#3	Integer	1	32767	1	1	
Deadband Cont.I#4	Integer	1	32767	1	1	
Deadband Cont.I#5	Integer	1	32767	1	1	
Deadband Cont.I#6	Integer	1	32767	1	1	
Deadband Cont.I#7	Integer	1	32767	1	1	
Deadband Cont.I#8	Integer	1	32767	1	1	
Deadband Cont.I#9	Integer	1	32767	1	1	
Deadband Cont.I#10	Integer	1	32767	1	1	
Deadband Cont.I#11	Integer	1	32767	1	1	
Deadband Cont.I#12	Integer	1	32767	1	1	
Deadband Cont.I#13	Integer	1	32767	1	1	
Deadband Cont.I#14	Integer	1	32767	1	1	
Deadband Cont.I#15	Integer	1	32767	1	1	
Deadband Cont.I#16	Integer	1	32767	1	1	
Deadband Cont.I#17	Integer	1	32767	1	1	
Deadband Cont.I#18	Integer	1	32767	1	1	
Deadband Cont.I#19	Integer	1	32767	1	1	
DNP Port 1 Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Baud rate	**Integer**	**300**	**38400**	**38400**	**300 600 1200 2400 4800 9600 19200 38400**	**baud**
Stop Bits	**Integer**	**1**	**2**	**1**	**1**	
Parity	**Integer**	**None Odd Even**	**None Odd Even**	**None**	**None Odd Even**	
Rx Time btw. Char	**Float**	**1**	**60000**	**0.5**	**40**	**msec.**
Comms Fail Ind. Time	**Float**	**0**	**600**	**0.1**	**60**	**s**

Advanced Settings						
Flow control						
CTS Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Sensitive	Bool	No Yes	No Yes	No	No Yes	
DTR Control	Integer	Inactive Active Rec. Req.	Inactive Active Rec. Req.	Inactive	Inactive Active Rec. Req.	
RTS Control	Integer	Inactive Active Rec. Req. Sen. Req.	Inactive Active Rec. Req. Sen. Req.	Inactive	Inactive Active Rec. Req. Sen. Req.	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO DCD	NO ECHO DCD	NO	NO ECHO DCD	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

DNP Port 2 and 3 Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Protocol Select	Uinteger	Procome Dnp3 Modbus	Procome Dnp3 Modbus	Procome	Procome Dnp3 Modbus	
Baud rate	Integer	300	38400	38400	300 600 1200 2400 4800 9600 19200 38400	baud
Stop Bits	Integer	1	2	1	1	
Parity	Integer	None Odd Even	None Odd Even	None	None Odd Even	
Rx Time btw. Char	Float	1	60000	0.5	40	msec.
Comms Fail Ind. Time	Float	0	600	0.1	60	s

Advanced Settings						
Operating Mode	Integer	RS-232 RS-485	RS-232 RS-485	RS-232	RS-232 RS-485	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Wait N Bytes 485	Integer	0	4	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO	NO ECHO	NO	NO ECHO	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

✓ All settings remain unchanged after a power loss. F4

DNP Protocol Configuration

- Relay Number (**RTU Address**):
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses.*
- T Confirm Timeout **(N7 Confirm Timeout)** :
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- Max Retries **(N7 Retries)** :
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- Enable Unsolicited **(Enable Unsolicited Reporting)** :
  Enables or disables Unsolicited reporting.
- Enable Unsol. after Restart :
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.
- Unsolic. Master No. (**MTU Address)** :
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- Unsol. Grouping Time **(Unsolicited Delay Reporting)** :
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- Synchronization Interval
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- DNP 3.0 Rev.
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)
- Binary Changes CLASS.
  election to send Binary Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Analog Changes CLASS.
  election to send Analog Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Counter Changes CLASS.
  election to send Counter Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Binary Status .
  end Binary with status otherwise without status
- 32 Bits Analog Input .
  end Analog All Variations and Analog Change Event Binary Changes with 32 bits otherwise with 16 bits

DNP Port 1 Port 2 and Port 3 Configuration

- **Number of Zeros (Advice_Time) :**
  Number of zeros before the message.
- **Max Retries (N1 Retries) :**
  Number of retries of the Physical Layer after collision detection.
- **Min Retry Time (Fixed_delay) :**
  Minimum time to retry of the Physical Layer after collision detection.
- **Max Retry Time :**
  Maximum time to retry of the Physical Layer after collision detection.
- **Collision Type :**

  Port 1:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link).

  Port 2:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link.

  DCD (Data Carrier Detect) based on detecting out-of-band carrier.

  If the device prepares to transmit and finds the link busy, it waits until is no longer busy, and then waits a backoff_time as follows:

  backoff_time = Min Retry Time + random(Max Retry Time - Max Retry Time)

  and transmit. If the device has a collision in transmission the device tries again ,up to a configurable number of retries (Max Retries) if has news collision.

- **Wait N Bytes 485:**
  Number of wait bytes between Reception and transmission Use Port 2 Operate Mode RS-485 .

Dnp3 Profile II Ethernet

(Version 02.60.00 is the first Software Version that supports this Profile)

Dnp3 Profile II Ethernet

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IRV

☐ ☒

Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS		
Function Codes	Bits 7 6 5 4 3 2 1 0: [7] (shaded), [6 5 4] Index Size, [3 2 1 0] Qualifier Code	
	Index Size	**Qualifier Code**
1 Read 2 Write 3 Select 4 Operate 5 Direct Operate 9 Direct Operate-No ACK 10 Immediate Freeze 11 Immediate Freeze no ACK 13 Cold Start 14 Warm Start 20 Enable Unsol. Messages 21 Disable Unsol. Messages 23 Delay Measurement 24 Record Current Time 129 Response 130 Unsolicited Message	0- No Index, Packed 1- 1 byte Index 2- 2 byte Index 3- 4 byte Index 4- 1 byte Object Size 5- 2 byte Object Size 6- 4 byte Object Size	0- 8-Bit Start and Stop Indices 1- 16-Bit Start and Stop Indices 2- 32-Bit Start and Stop Indices 3- 8-Bit Absolute address Ident. 4- 16-Bit Absolute address Ident. 5- 32-Bit Absolute address Ident. 6- No Range Field (all) 7- 8-Bit Quantity 8- 16-Bit Quantity 9- 32-Bit Quantity 11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (IRV parse)		RESPONSE (IRV respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
1	1	Binary Input	1	0,1,6,7,8	129	0,1	
2	0	Binary Input with Status	1	0,1,6,7,8	129	0,1	
2	0	Binary Input Change – All variations	1	6,7,8			
2	2	Binary Input Change with Time	1	6,7,8	129,130	17,,28	Assign to Event Class
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	Echo of request
20	0	Binary Counter – All variations	1	0,1,6,7,8			Assigned to Class 0.
20	1	32 Bits Binary Counter			129	0,1	
21	0	Frozen Counter – All variations	1	0,1,6,7,8			
21	1	32 Bits Frozen Counter			129	0,1	
22	0	Counter Change Event – All variations	1	6,7,8			
22	5	32 Bits Counter Change Event With Time			129,130	17,,28	Assign to Event Class
30	0	Analog Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	1	
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	1	
32	0	Analog Change Event – All variations	1	6,7,8			
32	3	32-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
32	4	16-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
50	1	Time and Date	2	7 count=1	129		C
50	3	Time and Date at Last Recorded Time	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (IRV parse)		RESPONSE (IRV respond)		
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes (dec)**	**Qual Codes (hex)**	**Notes**
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	129,130	28	D
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface ***ZIVercomPlus***). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1, 2 and 3) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured "on", then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as 128** Binary Input Changes**,** 64 Analog Input Changes and 64 Counter Input Change**. If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- **Customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assign to Class.		
Index	Description	
0	*Configure by ZIVercomPlus*® 2048 points	
1	*Configure by ZIVercomPlus*® 2048 points	
2	*Configure by ZIVercomPlus*® 2048 points	
3	*Configure by ZIVercomPlus*® 2048 points	
4	*Configure by ZIVercomPlus*® 2048 points	
5	*Configure by ZIVercomPlus*® 2048 points	
6	*Configure by ZIVercomPlus*® 2048 points	
7	*Configure by ZIVercomPlus*® 2048 points	
8	*Configure by ZIVercomPlus*® 2048 points	
9	*Configure by ZIVercomPlus*® 2048 points	
10	*Configure by ZIVercomPlus*® 2048 points	
11	*Configure by ZIVercomPlus*® 2048 points	
12	*Configure by ZIVercomPlus*® 2048 points	
13	*Configure by ZIVercomPlus*® 2048 points	
14	*Configure by ZIVercomPlus*® 2048 points	
15	*Configure by ZIVercomPlus*® 2048 points	
16	*Configure by ZIVercomPlus*® 2048 points	
17	*Configure by ZIVercomPlus*® 2048 points	
...	*Configure by ZIVercomPlus*® 2048 points	
253	*Configure by ZIVercomPlus*® 2048 points	
254	*Configure by ZIVercomPlus*® 2048 points	
255	*Configure by ZIVercomPlus*® 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	Description	
0	*Configure by ZIVercomPlus*® 256 points	
1	*Configure by ZIVercomPlus*® 256 points	
2	*Configure by ZIVercomPlus*® 256 points	
3	*Configure by ZIVercomPlus*® 256 points	
4	*Configure by ZIVercomPlus*® 256 points	
5	*Configure by ZIVercomPlus*® 256 points	
6	*Configure by ZIVercomPlus*® 256 points	
7	*Configure by ZIVercomPlus*® 256 points	
8	*Configure by ZIVercomPlus*® 256 points	
9	*Configure by ZIVercomPlus*® 256 points	
10	*Configure by ZIVercomPlus*® 256 points	
11	*Configure by ZIVercomPlus*® 256 points	
12	*Configure by ZIVercomPlus*® 256 points	
13	*Configure by ZIVercomPlus*® 256 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
14	***Configure by ZIVercomPlus*⑧ 256 points**	
15	***Configure by ZIVercomPlus*⑧ 256 points**	
16	***Configure by ZIVercomPlus*⑧ 256 points**	
17	***Configure by ZIVercomPlus*⑧ 256 points**	
...	***Configure by ZIVercomPlus*⑧ 256 points**	
253	***Configure by ZIVercomPlus*⑧ 256 points**	
254	***Configure by ZIVercomPlus*⑧ 256 points**	
255	***Configure by ZIVercomPlus*⑧ 256 points**	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assign to Class		
Index	**Description**	**Deadband**
0	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_1.**
1	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_2.**
2	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_3.**
3	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_4.**
4	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_5.**
5	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_6.**
6	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_7.**
7	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_8.**
8	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_9.**
9	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_10.**
10	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_11.**
11	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_12.**
12	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_13.**
13	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_14.**
14	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_15.**
15	***Configure by ZIVercomPlus*⑧ 256 points**	**() Deadband_16.**

Additional assign with ***ZIVercomPlus***⑧:

Index	Description
16	***Configure by ZIVercomPlus⑧ 256 points***
17	***Configure by ZIVercomPlus⑧ 256 points***
18	***Configure by ZIVercomPlus⑧ 256 points***
19	***Configure by ZIVercomPlus⑧ 256 points***
20	***Configure by ZIVercomPlus⑧ 256 points***
21	***Configure by ZIVercomPlus⑧ 256 points***
22	***Configure by ZIVercomPlus⑧ 256 points***
23	***Configure by ZIVercomPlus⑧ 256 points***
24	***Configure by ZIVercomPlus⑧ 256 points***
25	***Configure by ZIVercomPlus⑧ 256 points***
26	***Configure by ZIVercomPlus⑧ 256 points***
27	***Configure by ZIVercomPlus⑧ 256 points***
....	***Configure by ZIVercomPlus⑧ 256 points***
62	***Configure by ZIVercomPlus⑧ 256 points***
63	***Configure by ZIVercomPlus⑧ 256 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	Full Scale Range		
	Engineering units	Counts	
Currents (Phases, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**◊ Deadband**
Currents (Ground, polarizing)	0 to 1,2 x In_{GROUND} A	0 to 32767	**◊ Deadband**
Currents (Ground sensitive, isolated neutral)	0 to 1,2 A	0 to 32767	**◊ Deadband**
Voltages (Phase to ground, sequences, harmonics)	0 to 1,2 x Vn/√3 V	0 to 32767	**◊ Deadband**
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	**◊ Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	**◊ Deadband**
Power factor	-1 to 1	-32768 to 32767	**◊ Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**◊ Deadband**
Thermal value	0 to 200%	0 to 32767	**◊ Deadband**
Distance to Fault - **Percentage of line length:** 100% sends 32767 counts (range from -100% to 100%) - **Distance in kilometers:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in km) - **Distance in miles:** with the "line length" sends 32767 counts (range from - "line length" to the "line length" set in miles)		-32768 to 32767	**◊ Deadband**

Communication Measure in Counts

With ***ZIVercomPlus*** program is possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de Magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Max Communication:** it's a constant that depend of the Number Bits of Analog Input.
  Max Communication=2(Number Bits Analog Input - 1)**
  For 16-Bit Analog Input (Obj. 30 Var. 2) 2**(15) = 32.767 counts
  For 32-Bit Analog Input (Obj. 30 Var. 1) 2**(31) = 2.147.483.647 counts
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** This *flag* defines if the **limit** is proportional to the **rated value** of the magnitude.
- **TR:** Secondary to Primary Transformation Ratio.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times \frac{MaxComunication}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times \frac{MaxComunication}{Limit}$$

Communication Measure in Engineering Units

With ***ZIVercomPlus*** program **also** it's possible to transmit each magnitude in Engineering Units. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the **rated value** of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.
- **TR:** Secondary to Primary Transformation Ratio.
- **Scaling Factor:** Multiply Factor of magnitude.

Mathematical expression to obtain **Measure in Engineering Units** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times ScalingFactor$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times ScalingFactor$$

DeadBands

- Deadband is an area of a magnitude range or band where no generate magnitude change (the magnitude is dead). Meaning that no generation of Analogical Change Events if difference with value of generation of previous change is not equal or greater that DeadBand calculated. There is an independent setting for each 16 Measures with change.
- A Deadband is calculated as a percentage defined in DeadBand Setting over value of **parameter Limit**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 0.0000% and 100.00%, in steps of 0.0001%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Magnitude with change.

BINARY COUNTER (OBJECT 20) -> Assigned to Class 0.
FROZEN COUNTER (OBJECT 21)

32 BIT COUNTER CHANGE EVENT (OBJECT 22) -> Assign to Class

Index	Description	Deadband
0	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_1.**
1	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_2.**
2	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_3.**
3	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_4.**
4	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_5.**
5	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_6**
6	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_7.**
7	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_8.**
8	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_9.**
9	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_10.**
10	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_11.**
11	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_12.**
12	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_13.**
13	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_14.**
14	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_15.**
15	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_16.**
16	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_17.**
17	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_18.**
18	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_19.**
19	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_20.**

CounterDeadBands

- CounterDeadband is an area of a counter magnitude range or band, where no generate counter magnitude change (the communication counter magnitude is dead).Meaning that no generation of Counter Change Events if difference with value of generation of previous change is not equal or greater that CounterDeadBand setting. There is an independent setting for each Counter.

- The CounterDeadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 1 and 32767, in steps of 1, default value is 1.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings						
DNP Protocol Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
Binary Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 1	None Class 1 Class 2 Class 3	
Analog Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 2	None Class 1 Class 2 Class 3	
Counter Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 3	None Class 1 Class 2 Class 3	
Binary Status Change	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	
32 Bits Analog Input	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	
Analog Inputs (Deadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband AI#0	Float	0 %	100 %	100 %	0.0001 %	
Deadband AI#1	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#2	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#3	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#4	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#5	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#6	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#7	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#8	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#9	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#10	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#11	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#12	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#13	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#14	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#15	Float	0 %	100 %	100 %	0. 0001 %	

Counter Inputs (CounterDeadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband Cont.I#0	Integer	1	32767	1	1	
Deadband Cont.I#1	Integer	1	32767	1	1	
Deadband Cont.I#2	Integer	1	32767	1	1	
Deadband Cont.I#3	Integer	1	32767	1	1	
Deadband Cont.I#4	Integer	1	32767	1	1	
Deadband Cont.I#5	Integer	1	32767	1	1	
Deadband Cont.I#6	Integer	1	32767	1	1	
Deadband Cont.I#7	Integer	1	32767	1	1	
Deadband Cont.I#8	Integer	1	32767	1	1	
Deadband Cont.I#9	Integer	1	32767	1	1	
Deadband Cont.I#10	Integer	1	32767	1	1	
Deadband Cont.I#11	Integer	1	32767	1	1	
Deadband Cont.I#12	Integer	1	32767	1	1	
Deadband Cont.I#13	Integer	1	32767	1	1	
Deadband Cont.I#14	Integer	1	32767	1	1	
Deadband Cont.I#15	Integer	1	32767	1	1	
Deadband Cont.I#16	Integer	1	32767	1	1	
Deadband Cont.I#17	Integer	1	32767	1	1	
Deadband Cont.I#18	Integer	1	32767	1	1	
Deadband Cont.I#19	Integer	1	32767	1	1	
DNP Port 1 Port 2 and 3 DNP 3 Profile II Ethernet Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Enable Ethernet Port	**Boolean**	**0 (No)**	**1 (Yes)**	**1 (Yes)**	**1**	
IP Address Port 1	**Byte[4]**	**ddd.ddd.ddd.ddd**	**ddd.ddd.ddd.ddd**	**192.168.1.51**	**1**	
IP Address Port 2	**Byte[4]**	**ddd.ddd.ddd.ddd**	**ddd.ddd.ddd.ddd**	**192.168.1.61**	**1**	
IP Address Port 3	**Byte[4]**	**ddd.ddd.ddd.ddd**	**ddd.ddd.ddd.ddd**	**192.168.1.71**	**1**	
Subnet Mask	**Byte[4]**	**128.0.0.0**	**255.255.255.254**	**255.255.255.0**	**1**	
Port Number	**Uinteger**	**0**	**65535**	**20000**	**1**	
Keepalive Time	**Float**	**0**	**65**	**30**	**60**	**s.**
Rx Time Characters	**Float**	**1**	**60000**	**1**	**0.5**	**ms.**
Comms Fail Timer	**Float**	**0**	**600**	**60**	**0.1**	**s.**

✓ **All settings remain unchanged after a power loss.**

DNP Protocol Configuration

- Relay Number (**RTU Address**):
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- T Confirm Timeout (**N7 Confirm Timeout**) :
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- Max Retries (**N7 Retries**) :
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- Enable Unsolicited (**Enable Unsolicited Reporting**) :
  Enables or disables Unsolicited reporting.
- Enable Unsol. after Restart :
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.
- Unsolic. Master No. (**MTU Address**) :
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- Unsol. Grouping Time (**Unsolicited Delay Reporting**) :
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- Synchronization Interval
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- DNP 3.0 Rev.
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)
- Binary Changes CLASS.
  election to send Binary Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Analog Changes CLASS.
  election to send Analog Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Counter Changes CLASS.
  election to send Counter Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Binary Status .
  end Binary with status otherwise without status
- 32 Bits Analog Input .
  end Analog All Variations and Analog Change Event Binary Changes with 32 bits otherwise with 16 bits

DNP PROFILE II ETHERNET Port 1 Port 2 and Port 3 Configuration

- **Enable Ethernet Port :**
  Enables or disables Ethernet Port.

- **IP Address :**
  Identification Number of Ethernet device.

- **Subnet Mask :**
  Indicate the part of IP Address is the Net Address and the part of IP Address is the Device Number.

- **Port Number :**
  Indicate to Destinatión Device the path to send the recived data.

- **Keepalive Time :**
  Number of second between Keepalive paquets, if zero no send packages Keepalive. These packages allow to Server know if a Client is present in the Net.

- **Rx Time Between Characters :**
  Maximum time between Characters.

- **Comm Fail Timer :**
  Maximum time between Messages without indicate Communication Fail.

C. MODBUS RTU Documentation. Address Map

C.1 Preliminary Information

This a reference document for implementing the MODBUS RTU protocol in the **6IRV** IED.

This document provides a detailed MODBUS address map (input status, coil status, input registers and force single coil) and their equivalent in the **6IRV** relay.

The functions that will be implemented are:

ModBus Function	Meaning
01	Read Coil Status
02	Read Input Status
04	Read Input Registers
05	Force Single Coil

Any other function not among those indicated will be considered illegal and will return exception code 01 (Illegal function).

C.2 Function 01: Read Coil Status

C.2.1 Modbus Address Map for 6IRV

The MODBUS coil status address map for the **6IRV** relay will be:

Address	Description
Configurable through the *ZivercomPlus*®	Any input or output logic signal from the protection modules or generated by the programmable logic.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 1023 and they are assigned automatically by the ***ZivercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal Data Address).

C.3 Function 02: Read Input Status

C.3.1 Modbus Address Map for 6IRV

The MODBUS input status address map for the **6IRV** relay will be:

Address	Description
Configurable through the *ZivercomPlus*®	Any input or output logic signal from the protection modules or generated by the programmable logic.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 1023 and they are assigned automatically by the ***ZivercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal Data Address).

C.4 Function 03: Read Holding Registers

C.4.1 Modbus Address Map for 6IRV

The MODBUS read holding registers address map for the **6IRV** relay will be:

Address	Description
Configurable through the *ZivercomPlus*®	Any input or output logic signal from the protection modules or generated by the programmable logic whose number of changes is to be measured.

Configurable through the ***ZivercomPlus***®: Counters can be created with any signal configured in the programmable logic or from the protection modules. The default counters are those of the real energies (positive and negative) and the reactive energies (capacitive and inductive).

The metering range of energies in primary values is from 100wh/varh to 6553.5 kWh/kVArh. This is the magnitude transmitted via communications. That is, one (1) count represents 100 wh/varh.

To obtain an energy counter with a higher maximum value, a “user magnitude” must be created using this counter. For example, dividing the value of the counter by 1000 and making the output of the divider the new magnitude yields an energy counter with a range from 100 kWh/kVArh to 6553.5 MWh/Mvarh; that is, one (1) count represents 100 kWh/varh.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 255 and they are assigned automatically by the ***ZivercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal Data Address).

C.5 Function 04: Read Input Registers

C.5.1 Modbus Address Map for 6IRV

The MODBUS read input registers address map for the **6IRV** relay will be:

Address	Description
Configurable through the *ZivercomPlus*®	Any magnitude measured or calculated by the protection or generated by the programmable logic. It is possible to select between primary and secondary values, taking into account the corresponding transformation ratios.

All the full scale values of the magnitudes are definable, and these magnitudes can be used to create **user values**. Some typical values are:

- Phase and sequence currents and harmonics: **Rated value I_{PHASE} + 20**% sends 32767 counts.
- Ground and synchronization currents: **Rated value I_{GROUND} + 20%** sends 32767 counts.
- Sensitive ground and isolated ground currents: **1.2 A** sends 32767 counts.
- Line-to-neutral and sequence voltages and harmonics: **(Rated value V / √3) + 20%** sends 32767 counts.
- Phase-to-phase and polarization voltages: **Rated value V + 20%** sends 32767 counts.
- Powers: 3 x 1.4 x Rated value I_{PHASE} x Rated value / √3 sends 32767 counts.
- Power factor: from **-1** to **1** sends from -32767 to 32767 counts.
- Frequency: from **0 Hz** to **1.2 x $Frequency_{RATED}$** (50Hz / 60Hz) sends 32767 counts.
- Thermal value: **240%** sends 32767 counts.
- Distance to the fault:
  - Percentage value: **±100%** sends ±32767 counts (range from -100% to 100%).
  - Value in kilometers: with the "**length of the line**," it sends ±32767 counts (range from 0 km to the length of the line set in km. It can also send negative values).
  - Value in miles: with the "**length of the line**," it sends ±32767 counts (range from 0 km to the length of the line set in miles. It can also send negative values).

With the ***ZivercomPlus***® program, it is possible to define the full-scale value to be used to transmit this magnitude in counts, the unit that all the protocols use. There are three definable parameters that determine the range of distance covered:

- **Offset value**: the minimum value of the magnitude for which 0 counts are sent.
- **Limit**: the length of the range of the magnitude on which it is interpolated to calculate the number of counts to send. If the offset value is 0, it coincides with the value of the magnitude for which the defined maximum of counts (32767) is sent.
- **Nominal flag**: this flag allows determining whether the limit set is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user in the programmable logic can be configured, while the rest of the existing magnitudes are fixed.

The expression that allows defining this full-scale value is the following:

- When the Nominal flag is enabled,

$$CommunicationsMeasurement = \frac{Measurement - Offset}{Nominal} \times \frac{32767}{Limit}$$

- When the Nominal flag is NOT enabled,

$$CommunicationsMeasurement = (Measurement - Offset) \times \frac{32767}{Limit}$$

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 255 and they are assigned automatically by the ***ZivercomPlus®*** program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal Data Address).

C.6 Function 05: Force Single Coil

C.6.1 Modbus Address Map for 6IRV

The MODBUS force single coil address map of the **6IRV** relay will be:

Address	Description
Configurable through the *ZivercomPlus®*	A command can be made on any input from the protection modules and on any signal configured in the programmable logic.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 255 and they are assigned automatically by the ***ZivercomPlus®*** program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal Data Address).

Any value other than 00H or FFH will be considered illegal and will return exception code 03 (Illegal Data Value).

D. Schemes and Drawings

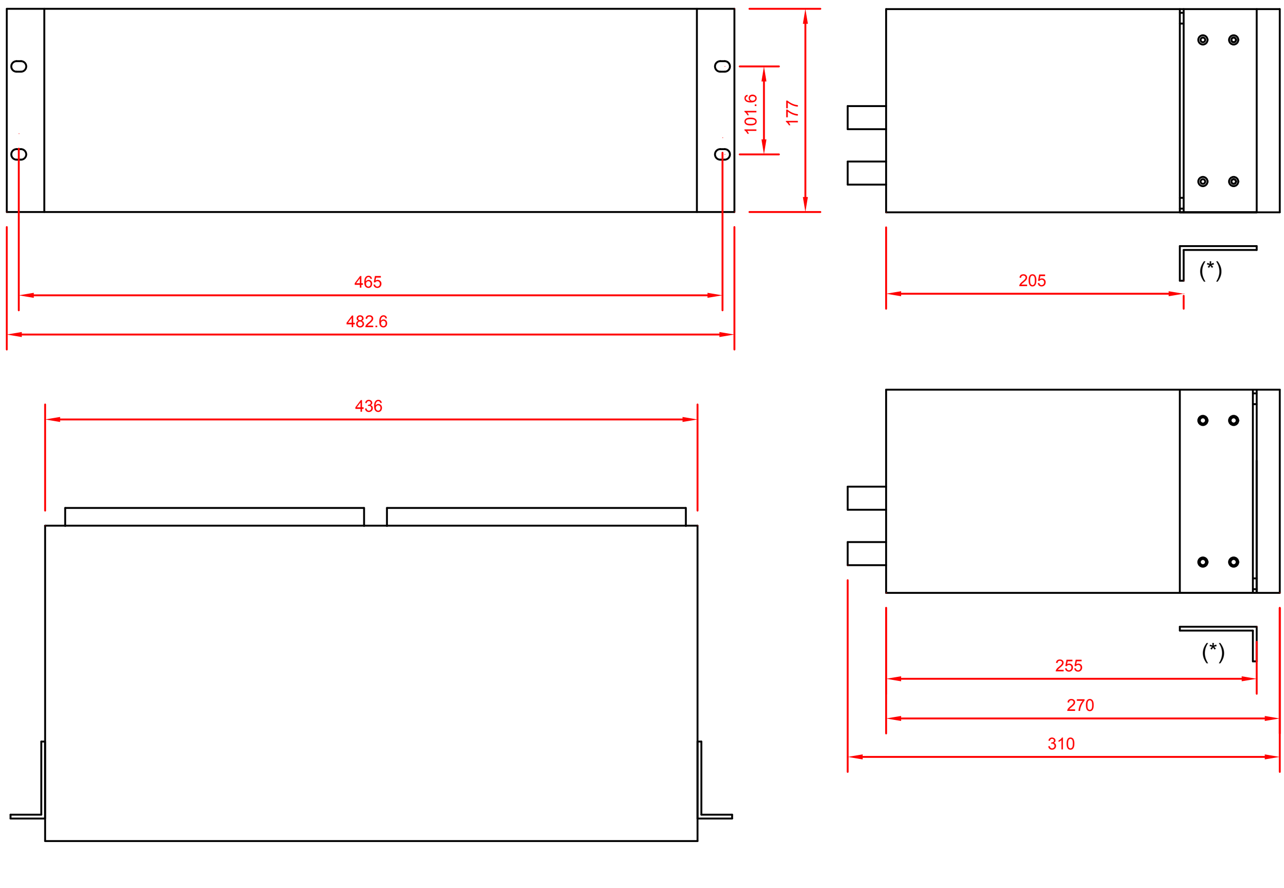
Dimension and Drill Hole Schemes

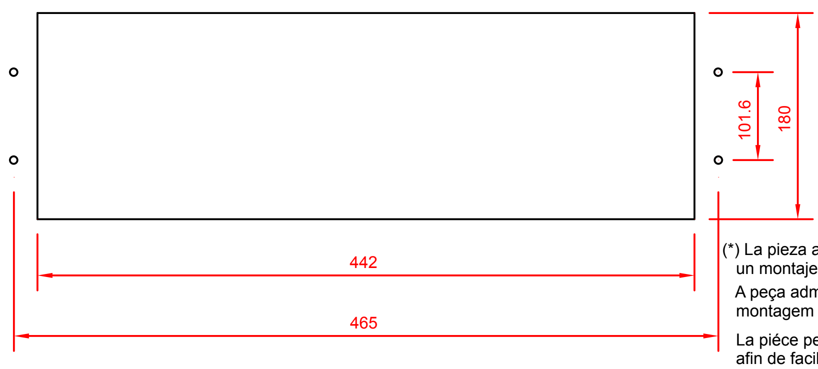
4U x 1 19” rack	>>4BF0100/0037
6U x 1 19” rack	>>4BF0100/0043

External Connection Schemes

6IRV-A	>>3RX0184/0110 (GENERIC)
6IRV-B	>>3RX0184/0108 (GENERIC)

CAJA TIPO "Q"
CAIXA TIPO "Q"
BOÎTIER TYPE "Q"
ENCLOSURE TYPE "Q"





TALADROS 8mm Ø
FUROS 8mm Ø
PERÇAGES 8mm Ø
8mm Ø DRILLING

(*) La pieza admite las 2 posiciones mostradas para facilitar un montaje mas o menos saliente.
A peça admite as 2 posiçoes mostrãdas para facilitar uma montagem do equipamento mais ou menos saliente.
La piéce peut être montée dans une des deux positions indiquées afin de faciliter le montage de l`equipement plus ou moinx proéminent.
Two mounting positions are posible, as shown, to vary the depth of the unit with respect to the cabinet.

REVISIONES		0	CD0407129	1	CD0504115
2	CD0901130	3	CD1102123	4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

Z I V Aplicaciones y Tecnología S.A.

TITULO> DIMENSIONES Y TALADRADO

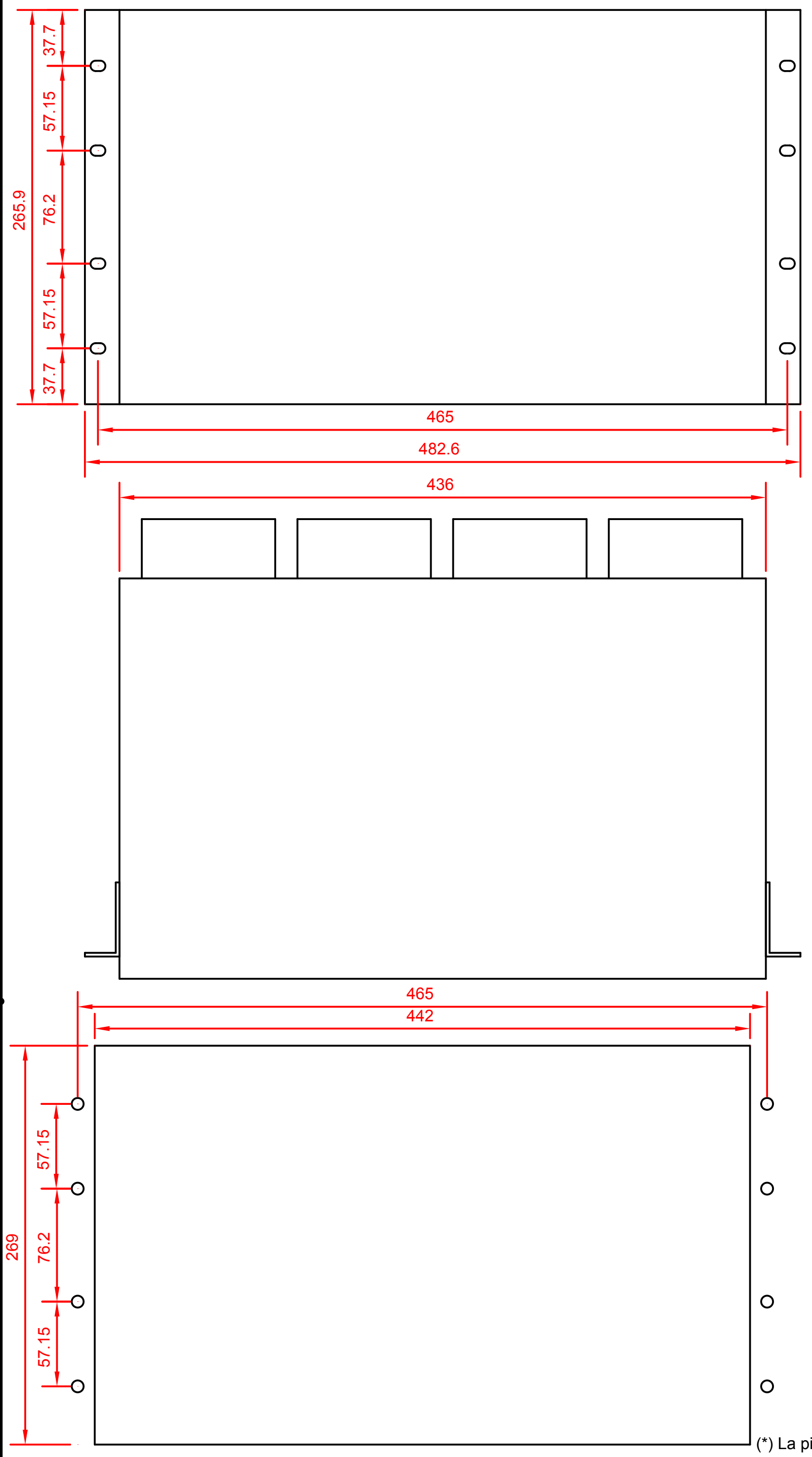
PROYECTO> CAJA TIPO "Q" 4U 1RACK (IDV)

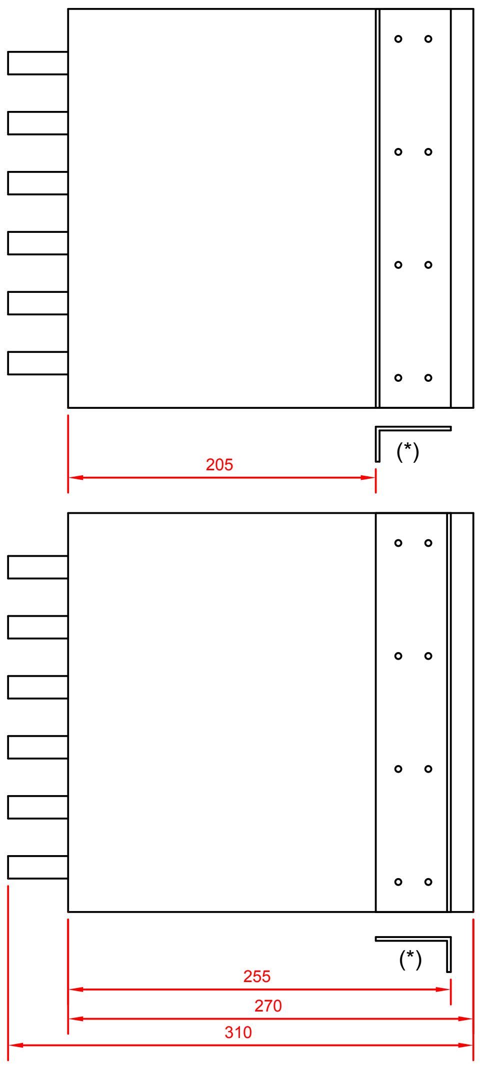
Rev. 0
Rev. 1 12/4/05
Rev. 2 10/2/09
Rev. 3 22/2/11

NUMERO> 4BF0100/0037

	Fecha	Nombre
Dibujado	07/09/04	J.C.S.
Aprobado	07/09/04	J.M.Y.

Hoja: 1
Continua en Hoja:





CAJA TIPO "V"
CAIXA TIPO "V"
BOÎTIER TYPE "V"
ENCLOSURE TYPE "V"

TALADROS 8mm Ø
FUROS 8mm Ø
PERÇAGES 8mm Ø
8mm Ø DRILLING

(*) La pieza admite las 2 posiciones mostradas para facilitar un montaje mas o menos saliente.

A peça admite as 2 posiçoes mostrãdas para facilitar uma montagem do equipamento mais ou menos saliente.

La piéce peut être montée dans une des deux positions indiquées afin de faciliter le montage de l`equipement plus ou moinx proéminent.

Two mounting positions are posible, as shown, to vary the depth of the unit with respect to the cabinet.

REVISIONES	0	CD0504145	1	CD0901130
2	3		4	
5	6		7	
8	9		10	
11	12		13	
14	15		16	

Z I V Aplicaciones y Tecnología S.A.

TITULO> DIMENSIONES Y TALADRADO

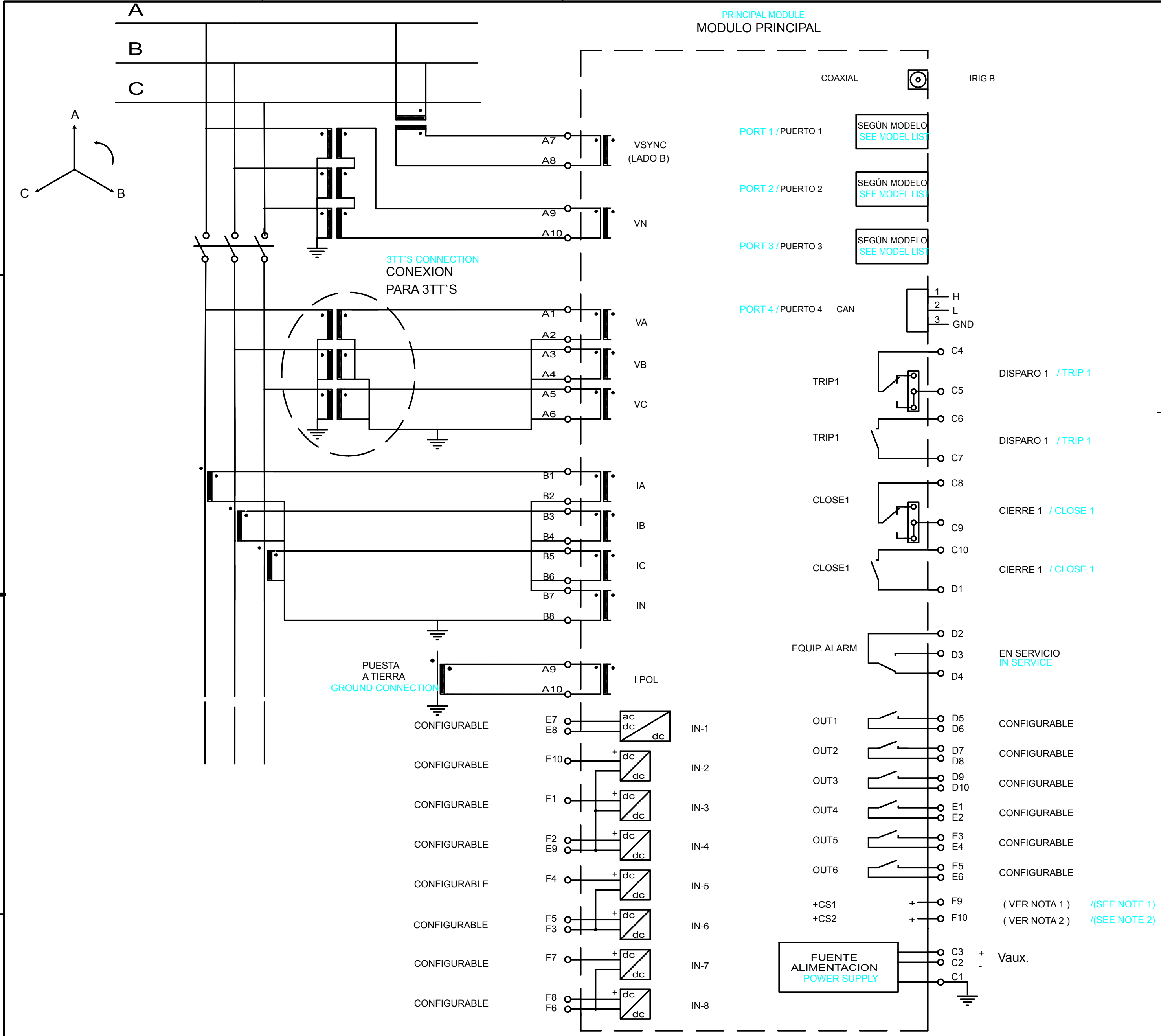
PROYECTO> CAJA TIPO "V" 6U 1RACK

Rev. 0
Rev. 1 10/2/09

NUMERO> 4BF0100/0043

	Fecha	Nombre
Dibujado	27/04/05	U.G.
Aprobado	27/04/05	C.G.G.

Hoja: 1
Continua en Hoja:



LEDS

1. - CONFIGURABLE
2. - CONFIGURABLE
3. - CONFIGURABLE
4. - CONFIGURABLE
5. - CONFIGURABLE
6. - CONFIGURABLE
7. - CONFIGURABLE
8. - CONFIGURABLE
9. - CONFIGURABLE
10. - CONFIGURABLE
11. - CONFIGURABLE
12. - CONFIGURABLE
13. - CONFIGURABLE
14. - CONFIGURABLE
15. - CONFIGURABLE
16. - CONFIGURABLE
17. - CONFIGURABLE
18. - CONFIGURABLE
19. - CONFIGURABLE
20. - CONFIGURABLE
21. - CONFIGURABLE
22. - CONFIGURABLE

SERIAL PORT
PUERTO SERIE

PIN	SIGNAL SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT
PUERTO SERIE
RS-232 / RS-485

PIN	SIGNAL SEÑAL
1	LIBRE / FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485-
7	LIBRE / FREE
8	LIBRE / FREE
9	LIBRE / FREE

SERIAL PORT
PUERTO SERIE
CAN

PIN	SIGNAL SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA F9 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3, IN4, IN5 o IN6 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 2: LA BORNA F10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN7, IN8 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTE 1: TERMINAL F9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

NOTE 2: TERMINAL F10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN7 OR IN8 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

REV.	0	CD1204111	1	2	3	4
5	6		7	8	9	10
11	12		13	14	15	16

Z I V Aplicaciones y Tecnología

TITULO: CON. EXT. 6IRV-A (3##)
TITLE: EXTERNAL CONNECTION 6IRV-A (3##)

PROYECTO /PROJECT: #IRV-A (Bornas W) /#IRV-A (W TERMINALS)

Rev. 0

NUM.: 3RX0184/0110

	Fecha /Date	Nombre /Name
Dibujado /Drawn	16/04/12	J.M.S.
Aprobado Approved	16/04/12	P.A.

Hoja /Sheet: 1

Continua en Hoja: 2
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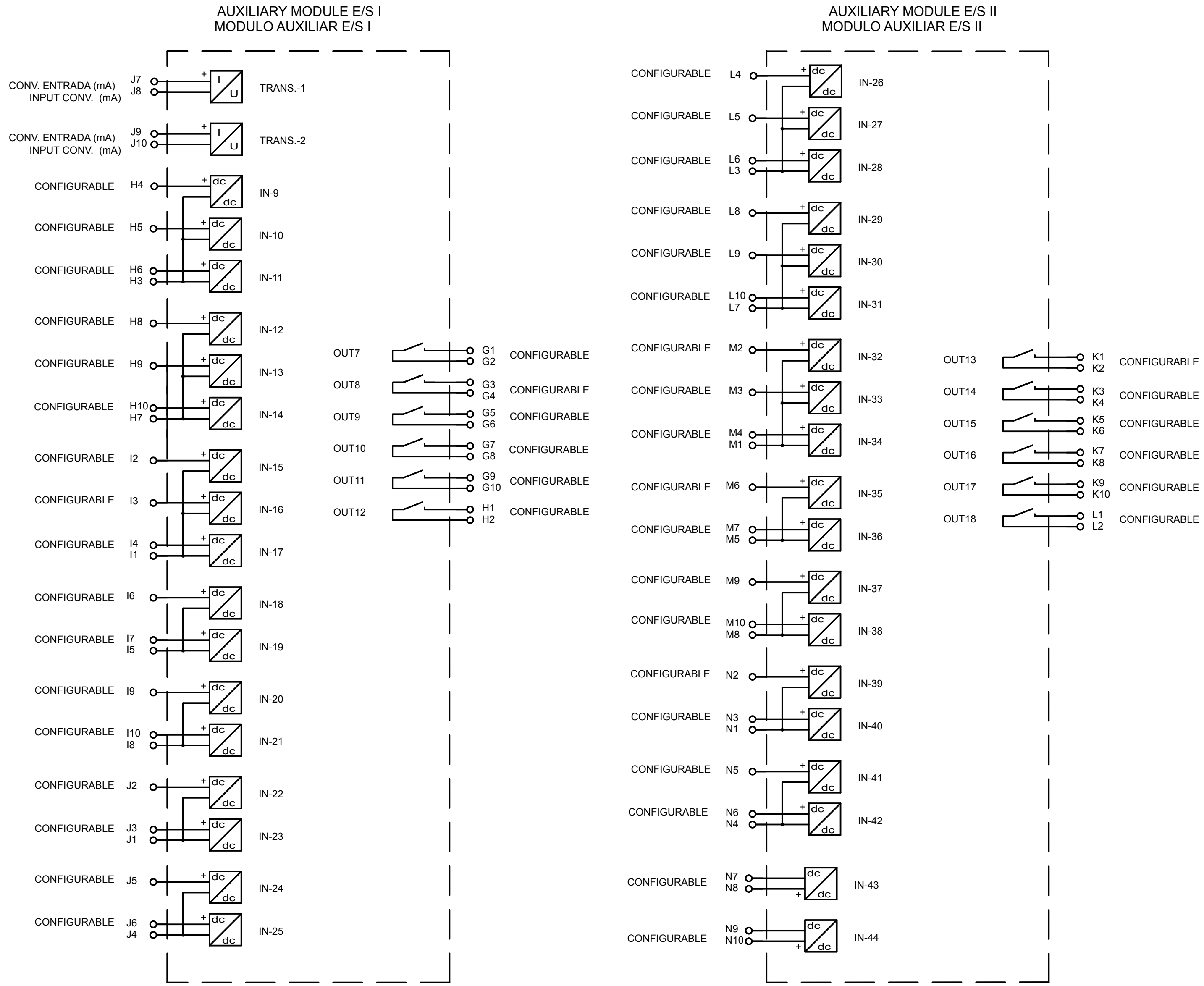

"ATENCION" "WARNING"

REV.	0	CD1204111	1		2		3		4	
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11		12		13		14		15		16

Z I V Aplicaciones y Tecnología

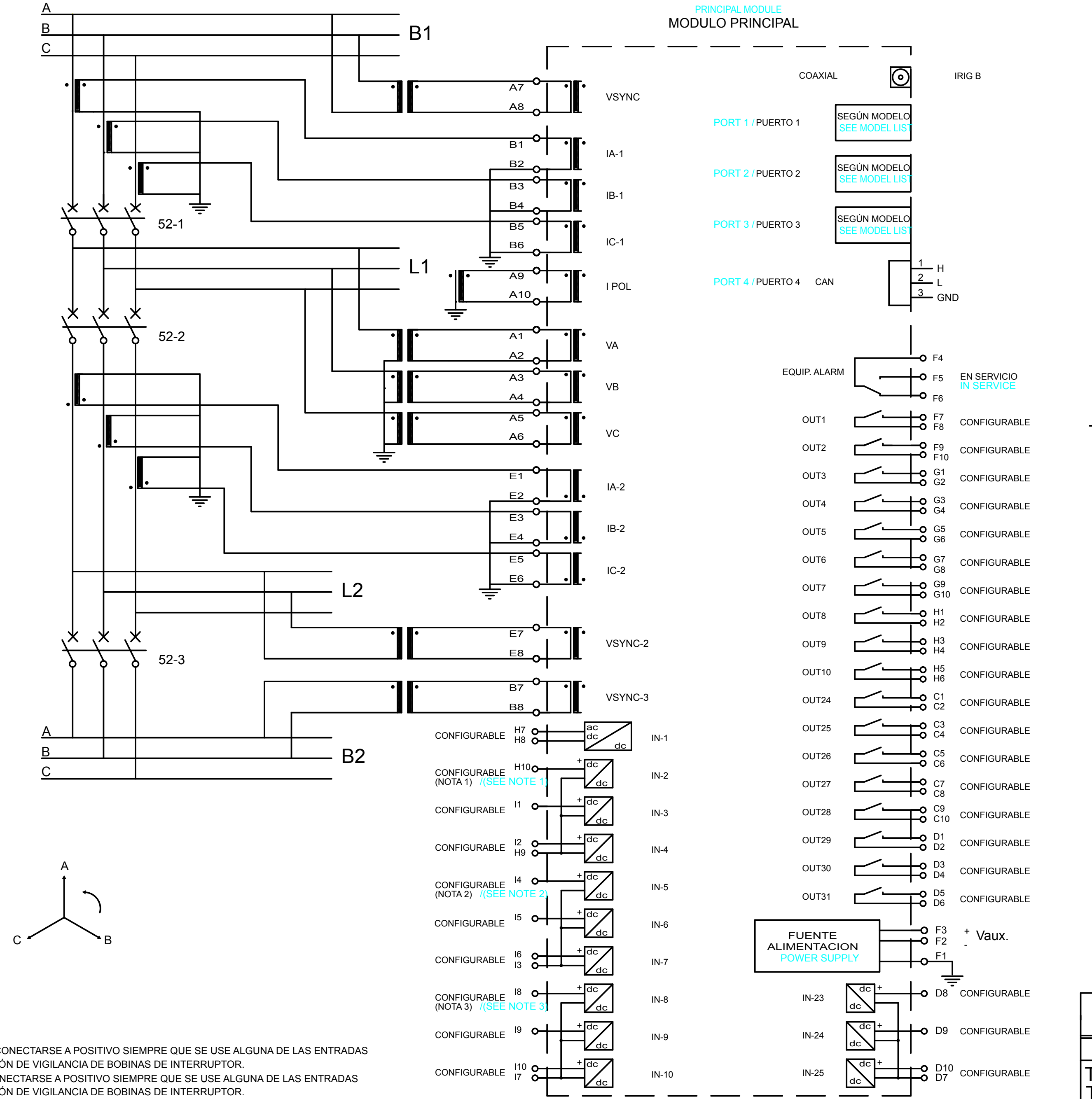
TITULO: CON. EXT. 6IRV-A (3##)
TITLE: EXTERNAL CONNECTION 6IRV-A (3##)

PROYECTO /PROJECT: #IRV-A (Bornas W) /#IRV-A (W TERMINALS)

Rev. 0 NUM.: 3RX0184/0110

	Fecha /Date	Nombre /Name
Dibujado /Drawn	16/04/12	J.M.S.
Aprobado /Approved	16/04/12	P.A.

Hoja /Sheet: 2
Continua en Hoja: -
Continued on sheet:



LEDS

1. - CONFIGURABLE	12. - CONFIGURABLE
2. - CONFIGURABLE	13. - CONFIGURABLE
3. - CONFIGURABLE	14. - CONFIGURABLE
4. - CONFIGURABLE	15. - CONFIGURABLE
5. - CONFIGURABLE	16. - CONFIGURABLE
6. - CONFIGURABLE	17. - CONFIGURABLE
7. - CONFIGURABLE	18. - CONFIGURABLE
8. - CONFIGURABLE	19. - CONFIGURABLE
9. - CONFIGURABLE	20. - CONFIGURABLE
10. - CONFIGURABLE	21. - CONFIGURABLE
11. - CONFIGURABLE	22. - CONFIGURABLE

SERIAL PORT / PUERTO SERIE

PIN	SIGNAL / SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT / PUERTO SERIE RS-232 / RS-485

PIN	SIGNAL / SEÑAL
1	LIBRE / FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485-
7	LIBRE / FREE
8	LIBRE / FREE
9	LIBRE / FREE

SERIAL PORT / PUERTO SERIE CAN

PIN	SIGNAL / SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3, IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6, IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9, IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTE 1: TERMINAL H10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3 OR IN4 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

NOTE 2: TERMINAL I4 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN6 OR IN7 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

NOTE 3: TERMINAL I8 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN9 OR IN10 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

REV.	0	CD1209107	1		2		3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnología

TITULO: CON. EXT. 6IRV-B (A##)
TITLE: EXTERNAL CONNECTION 6IRV-B (A##)

PROYECTO /PROJECT: #IRV-B (Bornas W) /#IRV-B (W TERMINALS)

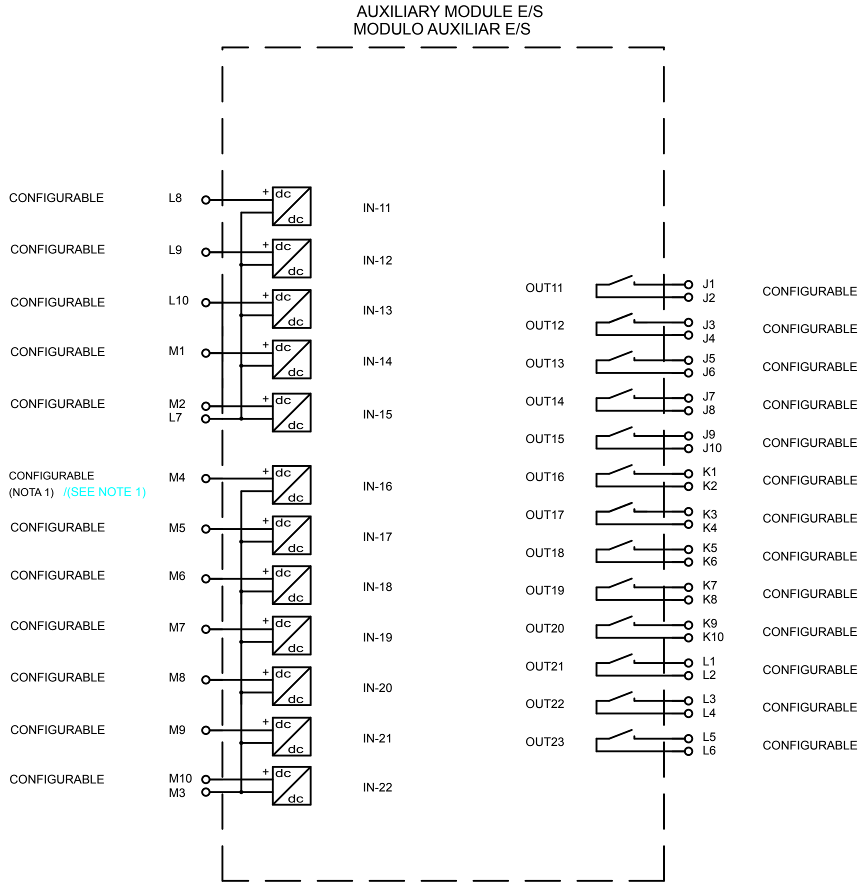
Rev. 0

NUM.: 3RX0184/0108

	Fecha /Date	Nombre /Name
Dibujado /Drawn	11/09/12	J.M.S.
Aprobado /Approved	11/09/12	P.A.

Hoja /Sheet: 1

Continua en Hoja: / Continued on sheet: 2



NOTA 1: LA BORNA M4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN17, IN18, IN19, IN20, IN21 o IN22 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTE 1: TERMINAL M4 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN17, IN18, IN19, IN20, IN21 OR IN22 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

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TITULO: CON. EXT. 6IRV-B (A##)
TITLE: EXTERNAL CONNECTION 6IRV-B (A##)

PROYECTO /PROJECT: #IRV-B (Bornas W) /#IRV-B (W TERMINALS)

Rev. 0 NUM.: 3RX0184/0108

	Fecha /Date	Nombre /Name
Dibujado /Drawn	11/09/12	J.M.S.
Aprobado /Approved	11/09/12	P.A.

Hoja /Sheet: 2
Continua en Hoja: / Continued on sheet: -

E. List of Illustrations and Tables

E.1 List of Figures

Annex E. List of Illustrations and Tables

E.2 List of Tables

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